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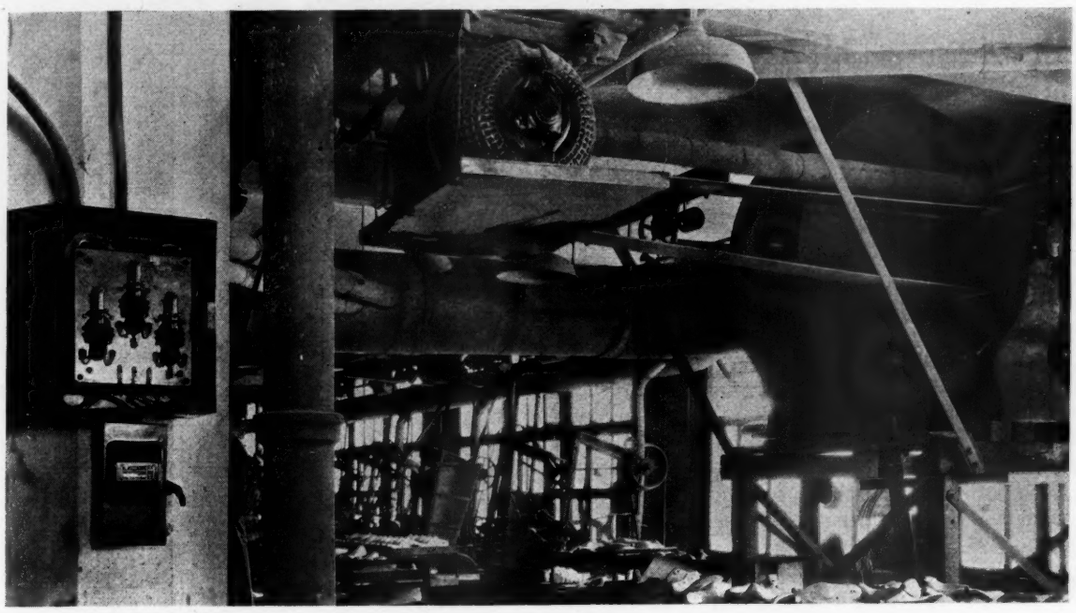

Fig. 1—A good example of an installation in which both the motor and its control are mounted out of the way, but are easily accessible.

Electrical Features of

Motor Installations

By GORDON FOX

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DEPENDABILITY of modern electric motors, even when operated under poor conditions, is so well known that there is frequently a tendency to concentrate attention on the selection and application and pay rather scant heed to the details of installation. However, the proper operation of a motor is obtained only when the principles of proper installation are fully understood and applied. This article will, therefore, discuss the considerations involved in the actual layout of a motor installation, with particular reference to the wiring limitations, protection necessary, and Code requirements.

In the location of a motor there is generally some room for choice. In any event, motors should, if possible, be located in a clean, light, and dry place, where sufficient ventilation may be provided and where they will be easily accessible. If excessive moisture is present, motors must be provided either with a covering to protect them from dripping water, or isolated in a separate room. Special treatment of the windings may be necessary under such conditions. Circumstances will usually determine whether a motor should be mounted on the floor, or the ceiling or elsewhere. Regardless of where the motor is mounted, one of the main considerations is to provide a strong, rigid support.

Frames of motors should be grounded. An exception may be allowed, if necessary, when it is impossible for an operator or attendant to make contact with the motor and with any grounded object at the same time. If the motor is not grounded the isolation must be complete. The safest practice is to ground the motor frame always. If the motor is not otherwise grounded, the conduit connection often serves this purpose.

The location of the point from which a motor is to be controlled is primarily a matter of convenience. The Code requires that the motor switch and starting device be located within sight of the motor, unless special permission is granted to do otherwise. Where magnetic control is used, this requirement is commonly interpreted as referring to the master station and not to the control panel, permitting each element to be located to the best advantage. With

Fig. 2—An enclosed, wall-mounted magnetic starter with hinged panel to give access to the resistors and connections.

this control it is frequently desirable or convenient to supply more than one master control station or perhaps an additional stop button. Where permissible, the controller or panel may be located between the motor and the source of power to obtain the most direct wiring runs.

The controller should not be unnecessarily exposed, either to damage, dirt or accidental contact. It should obviously be located so as to avoid swinging crane loads, trucks, and leaky pipes, and not too close to windows. There should be ample room for opening enclosing cabinet doors. Safety dictates that all live parts of manual controllers should be enclosed. For magnetic control, suitable protection may be provided either by enclosure or by isolation. Open panels should be installed only in clean, light rooms, accessible only to authorized persons. Otherwise, the control panels should be enclosed and possibly locked. Enclosure protects against both dirt and tampering. Magnetic control equipment will not long survive and function properly if subjected to frequent "adjustments" by machine operators; nor is such practice safe.

Magnetic controllers for small motors are usually arranged for wall mounting. The enclosing cabinets provided for many such control panels render access for repairs difficult. In some designs it is necessary to dismount the panel and remove it from the enclosing box to get at the resistors or connections on the rear of the panel. Enclosed, wall-mounted panels should be hinged to permit swinging of the panel, giving access to the rear without disturbing connections. This construction is now available from some manufacturers. An example of this construction is shown in Fig. 2. Large magnetic control panels are normally floor-mounted. When such panels are enclosed they are commonly located away from the wall, with access to the front and rear by separate doors. This construction is shown in Fig. 3.

Resistors for drum controllers of small horsepower rating are sometimes self-contained. Faceplate controllers commonly have the resistors integral. Magnetic starters of small capacity, notably the wall-mounted types, carry the resistors on the rear of the panel. Practically all other types and sizes of controllers have separate resistor banks. It is the writer's opinion that if resistors are self-contained, provision should be made for ready access to them. Otherwise, they should be separately mounted.

In stacking resistor frames, it is generally considered inadvisable to stack them more than three tiers high, as the heat rising from the lower tiers decreases the capacity of the upper tiers. The frames should be stacked so as to provide good ventilation and should preferably be individually mounted so that they may be removed for repairs or replacement as independent units. They should always be easily accessible. Enclosure in a grating generally leads to inaccessibility. Where subjected to shock, it is sometimes advisable to mount cast-iron grids with their plane in the direction of probable impact, in order to minimize breakage.

Some resistor frames are so constructed that the grids are insulated from the mounting rods, and the mounting rods, in turn, are insulated from the end frames. With this construction the end frames should be grounded. If the resistor mounting rods are not insulated from the end frames it is not uncommon practice

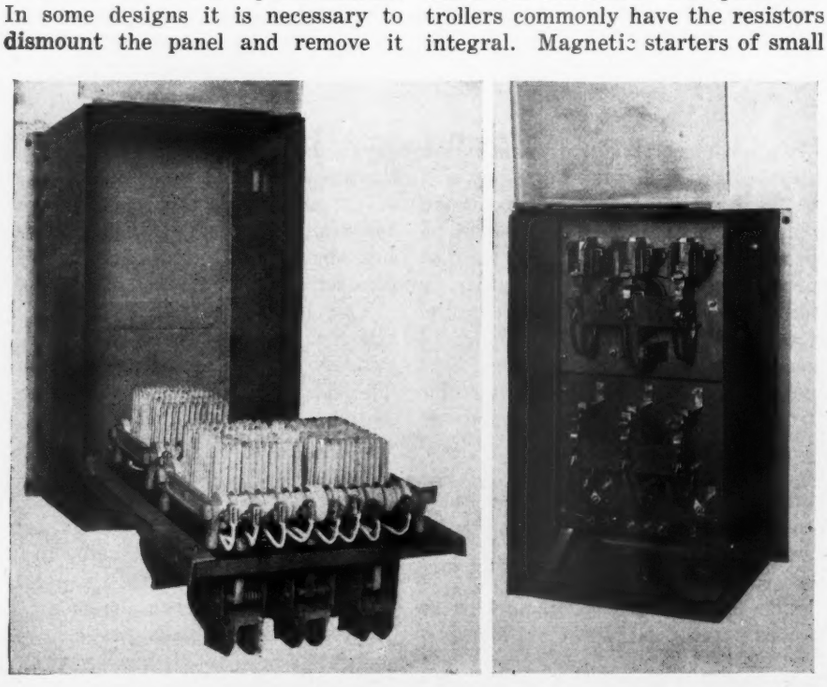

Fig. 3—This shows one type of enclosed, floor-mounted magnetic control panel.

Doors on the front and rear of the enclosing cabinet permit easy access to all parts for inspection or repairs.

to mount the resistor frames on oil-filled, hardwood timbers or otherwise to insulate them from the ground, thus lessening the probability of failure and trouble in the interest of continuity of service. Obviously the location of the timbers and the spacing must be such as to introduce no fire hazard.

This practice is, however, not in accordance with the Code. Moreover, it introduces a hazard due to the possibility that an end frame may become grounded and thus cause a shock. Fig. 4 shows a good form of steel rack for supporting resistor frames.

It is not the purpose of this article to treat on types of controllers, but it will not be out of place to say that the installation of the control with respect to the motor is of vital importance in making a successful application from the operating standpoint.

Many public utilities prescribe rules limiting the current peaks that are allowable in starting motors on their lines, which rules apply more particularly to alternating-current motors. A few companies follow an antiquated ruling which prohibits the installation of squirrel-cage induction motors larger than 30 hp., requiring wound-rotor motors above this size. The N.E.L.A. has formulated a code of requirements relating to the limitation of the starting current inrush of alternating-current motors. These rules are commonly followed by most public service companies. The essential features of these rules are as follows:

Instantaneous current peaks drawn from the line by a motor, with the starting device in the starting position, must not exceed the value for the rated horsepower of such motor

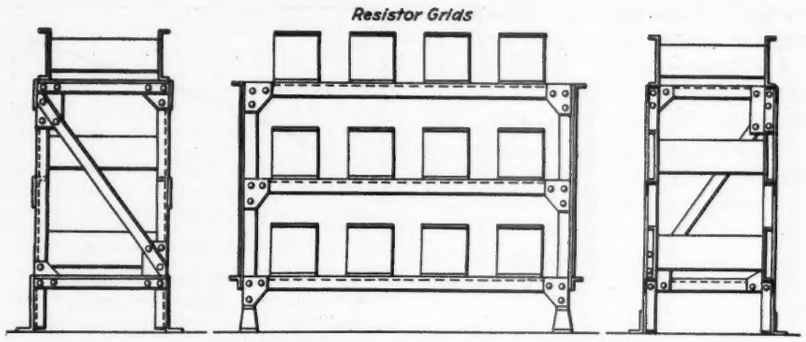

Fig. 4—A pipe or angle-iron framework makes a good mounting for resistors.

The rack shown here is made of angle iron. When mounting, ample space for ventilation should be allowed between resistors.

shown in Tables I or II. In a group installation the largest starting current permitted, in accord with the tables, for any one motor of the installation shall be the limit of starting current for any other motor of the group. This ruling generally means that the largest motor in a given installation is subject to limitation of starting current peaks in accord with the tables, but all limitations are removed as to the starting current of the smaller motors in the installation. The limits of starting current in Table II are intended to be such that reduced-voltage starting devices will be required for polyphase squirrel-cage motors of 7.5 hp. and above where the installation does not include larger motors. As previously stated, when larger motors are included in the installation, the starting current of the smaller motors is not restricted. Motors that cannot be safely subjected to full voltage at starting must be provided with a device to insure that on failure of voltage, (*a*) the motor will be disconnected from the line, or (*b*) the starting device will be returned to the starting position.

The largest single-phase motor to be permitted on one phase of polyphase systems should be 5 hp., larger sizes to be installed only after securing special permission.

Current values are those indicated by a suitable, well-damped ammeter in the motor circuit on the line side of the starting device and are 75 per cent of the permissible locked-rotor values. Where the current in one phase is higher than the currents in the other phases, the rule for limitation of current inrush applies to the phase having the highest current.

Particularly in view of the restriction of permissible current inrush under the N.E.L.A. rules, it is of interest and pertinent to consider the relations between motor current, line current and motor torque with different voltages applied to squirrel-cage induction motors when using both auto-transformer and resistance-type starters. These relations can be determined through the use of the curves in Figs. 5, 6 and 7.

Fig. 5 shows the relation between torque at standstill and the motor current that is necessary to produce this torque. This is an average curve applying to any make of motor, and for all sizes and speeds.

Fig. 6 shows the relation between the terminal voltage applied to the motor by a primary resistance starter, and the inrush current. This current is expressed in per cent of full-load current and applies to motors having from two to twelve poles, operating on either 25 or 60 cycles. When primary resistance starters are used, the motor current and line current are identical.

When the motor is started with an auto-transformer, the line current is not identical with the motor current. Because of the exciting current of the transformer and power factor considerations the line current is not reduced in full proportion to the reduction in the impressed voltage.

Table I—Maximum Starting Current for Single-Phase, 60-Cycle Motors*

	Volts	Amp.†
Rating 0.5 hp. and below	220	15
Above ½ hp. and to 1 hp., inc.	220	20
		Amp. per Hp.
Above 1 hp. and up to 5 hp	220	15
Above 5 hp.‡	220	11

* N.E.L.A. Service Rules.

† Motors requiring not more than 30 amp. starting current may be connected for 110 volts.

‡ Permission must be obtained from public utility to install single-phase motors larger than 6 hp.

Table II—Maximum Starting Current for Three-Phase 60-Cycle Motors*

Hp. of Motor	Voltage	Line Current per Phase per Hp. Two-Phase	Three-Phase
1	220	17.3	20
1–2	220	15.2	17.5
3–5	220	11.2	13
	440	5.6	6.5
	550	4.5	5.2
6 to 30	220	8	9
	440	4	4.5
	550	3.2	3.6
Above 30	220	5.2	6
	440	2.6	3
	550	2.1	2.4
	2,300	0.5	0.6

*N.E.L.A. Service Rules.

Fig. 7 shows the line current as a function of the voltage applied to the motor terminals for motors having from two to twelve poles. On a three-phase system these data apply only to star-connected auto-transformers having three coils. When two-coil, open - delta - connected transformers are used, the current in the third phase will be approximately 15 per cent higher than the values given by these curves.

The application of these curves can be shown by an example. Consider the case of a 30-hp., 1,200-r.p.m., 440-volt, three-phase, 60-cycle, squirrel-cage induction motor. According to Table III the rated full-load current of this motor will be about 40 amp. According to Table II the highest permissible current inrush is 4.5 amp. per hp., or 135 amp. Let us determine what starting torque can be developed by this motor when using a primary resistance starter, under the N.E.L.A. ruling.

The permissible current inrush of 135 amp. is 340 per cent of the full-load current of 40 amp. From Fig. 5, it is seen that about 87 per cent of full-load torque can be developed with 340 per cent of full-load current inrush into the motor. From Fig. 6 it may be noted that about 68 per cent of full voltage should be impressed at the motor terminals to cause a current inrush of 340 per cent of full-load current. This voltage is found by interpolating between the 60 per cent and 80 per cent voltage values.

If a star-connected, three-coil auto-transformer type starter is used, the procedure is as follows: From Fig. 7 it will be found that 340 per cent full-load line inrush current will result if about 77 per cent of full voltage is impressed at the motor. From Fig. 6 it will be found that 77 per cent voltage applied to the motor will cause approximately 385 per cent of full-load current inrush to the motor (as differentiated from 340 per cent full-load inrush current). From Fig. 5 it is found that about 107 per cent of full-load torque will be developed with 385 per cent of full-load current.

If a two-coil, open-delta-connected auto-transformer type starter is used it is first necessary to reduce the permissible line current inrush 15 per cent, as from 340 per cent to 295 per cent, to correct the inequality of current in the three phases. In following the procedure as outlined it will be found that, in the case of the 30-hp. motor under consideration, about 95 per cent of full-load torque can be developed.

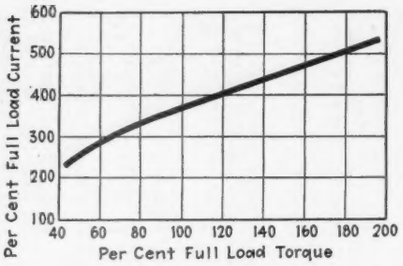

Fig. 5—Relation between torque of squirrel-cage induction motor at standstill and current required to produce this torque.

The values shown on this curve represent the average performance of squirrel-cage motors of any make, size or speed.

If a primary-resistance starter were to be considered, having resistance in only two of the three phases, the current in the third phase would be about 30 per cent higher than that in the other two phases. Then it would be necessary to reduce the permissible line current inrush value in the ratio of 100 ÷ 130, proceeding then as with a primary resistance starter having resistance in all three phases.

Neither the Code nor the Apparatus Division, National Electrical Manufacturers Association, formerly the Electric Power Club, prescribes any wiring standards for the connection between controllers and separately mounted resistors. For low-voltage circuits, below 600 volts, wire or cable having slow-burning insulation is recommended, as moisture is seldom involved and this insulation will best withstand the heat. For higher voltage circuits, such as secondary connections of large, wound-rotor induction motors, varnished-cambric-insulated, flameproof - braid cable is well suited.

In this connection it should be noted that if a wound-rotor induction motor is to be plugged the secondary voltage may reach nearly twice the nameplate value, which represents the locked-rotor voltage. Insulation should be provided accordingly.

Resistor connections may be run open or in conduit, as required. The usual care must be taken with alternating-current circuits to install similar leads of different phases in common conduits if iron conduit is used.

Inasmuch as starting resistor connections are in circuit a relatively brief time, it is not necessary that the wire or cable used have a continuous capacity equal to that of other portions of the motor circuit. The degree to which cables may be overloaded for this purpose depends upon the degree to which the service is intermittent. In the absence of a standard, the practice recommended by one of the foremost controller manufacturers will be given. Table IV shows the current ratings that may be given to wires or cables having slow-burning (class C) insulation for use in connection with resistors of the various duty classifications adopted by the former Electric Power Club.

The rated full-load current of the motor is the basis for selection. Thus a 25-hp., 230-volt, d.c. motor whose rating is 94 amp. at full load, used in connection with a heavy starting duty resistor, class 31 to 36, would

Table III—Cable Sizes for Three-Phase 440-Volt Alternating-Current Motors

Horse-power	Full Load, Amp.	110 Per Cent of Full Load, Amp.	Cable Size	125 Per Cent of Full Load, Amp.	Cable Size	Starting Current		Cable Size, Code Basis
						Per Cent Full Load Current	Current, Amp.	
1	1.8	2.0	14	2.3	14	250	4.5	14
3	4.8	5.3	14	6.0	14	250	12.0	14
5	7.8	8.6	14	9.8	14	250	19.5	12
7.5	11	12.1	14	13.8	14	250	27.5	8
10	15	16.5	12	18.8	12	250	37.5	6
15	21	23	10	26	8	250	52	5
20	27	30	8	34	6	250	68	4
25	34	38	6	43	6	200	68	4
30	40	44	6	50	6	200	80	3
40	52	57	4	65	4	200	104	0
50	65	72	3	82	2	200	130	00
75	96	105	0	120	0	200	192	0000
100	126	139	00	158	000	200	252	250,000
150	184	202	0,000	230	30,000	200	368	500,000
200	242	266	300,000	302	350,000	200	484	700,000

Use Column 4 for circuit from controller to motor for squirrel-cage and synchronous motor and for the entire circuit for wound-rotor motors.

Column 6 may be used for circuit ahead of controller for wound-rotor motors to permit larger line cutouts.

Use Column 9 for circuit ahead of controller for squirrel-cage and self-starting synchronous motors.

Use next larger wire size throughout for motors whose speed is below 600 r.p.m.

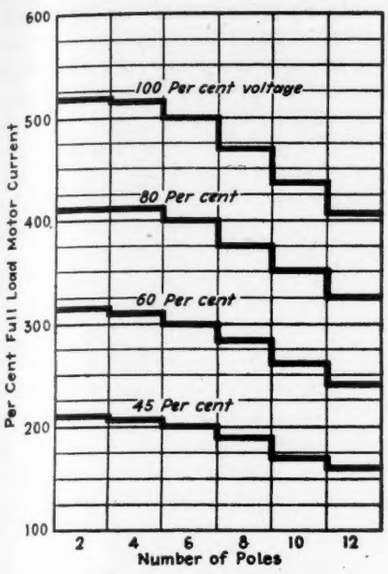

Fig. 6—This shows the relation between applied voltage and current inrush when starting a squirrel-cage motor with a primary-resistance starter.

These curves apply to motors having from two to twelve poles and operating on 25 or 60 cycles. Current values at starting are given in per cent of full-load current.

require No. 10 B. & S. gage cable for intermediate resistor connections. It should be understood that these current ratings are only for leads that are in circuit throughout an accelerating or braking period, or a part thereof. Resistor connections that are continuously in circuit are subject to Code rules and ratings.

Cables connecting to resistors should preferably be run below or to one side of the resistors, rather than above them, so that they will be subjected as little as possible to heat.

The most successful motor applications are those which have had intelligent direction and careful attention to the details of safeguarding not only the control but the motor and wiring as well.

Motors may be protected by fuses, by circuit breakers, or by relays functioning in connection with the motor controller. Fuses are satisfactory for many small motors, especially for drives of lesser importance where the delays incidental to fuse replacement are not serious, and for drives having definitely limited loads. Circuit breakers have an advantage in that they indicate their action, can be reset quickly and do not require very frequent renewal of parts. They combine the functions of fuse and switch, but are relatively high in first cost. This consideration limits their application to those services which justify the difference in cost, and such cases are numerous.

Circuit breakers that are installed for motor protection should be multipolar and arranged to disconnect all the feed lines at the same instant. In order to afford complete protection, direct-current circuit breakers should be provided with two trip coils, one in the positive and one in the negative line. Three-phase a.c. motors are fully protected by a three-pole circuit breaker having two series trip coils, or the current transformer equivalent thereof. An exception, however, occurs if the system has a grounded neutral. Three coils are then necessary. A two-phase, four-pole circuit breaker must have four trip coils, if full protection is to be obtained. If a lesser number of trip coils are used in any of the cases previously mentioned, the breaker may fail to open in case of a ground on this portion of the circuit.

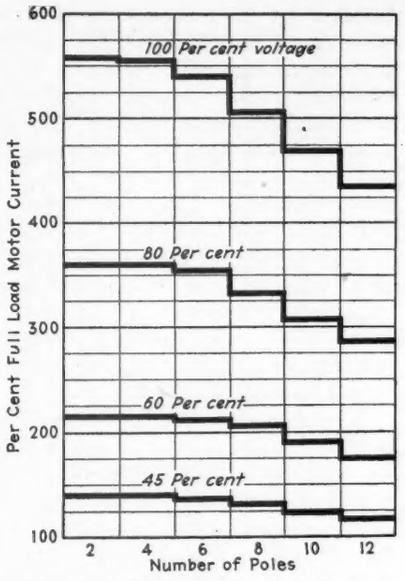

Fig. 7 — When a squirrel-cage motor is started with a three-coil auto-transformer the current and voltage relations are as shown in these curves.

As is the case of the curves in Fig. 6, those shown here apply to motors having from two to twelve poles.

The Code requires that a circuit breaker used as a motor cutout must have a continuous current rating of at least 110 per cent of the current rating of the motor. For motors of 550-volt rating and below, air circuit breakers are suitable for use as a motor switch and cutout ahead of the controller. Such a breaker will have a calibration range from about 75 per cent to 200 per cent of its rating, or from about 82 per cent to 220 per cent of the motor rating.

The writer prefers time-element circuit breakers for motor protection. These are essential when used to protect squirrel-cage induction motors or self-starting synchronous motors. The time-element feature prevents tripping of the breaker by the starting current peaks. For similar reasons the time-element breaker is to be preferred for use with other types of motors. The Code does not permit setting instantaneous trip breakers higher than 160 per cent of the motor rating. This setting is frequently insufficient to prevent tripping of the breakers while starting the motor. Moreover, an instantaneous trip

Table IV—Current Ratings of Cables (Class C Insulation) Used for Intermediate Connections to Resistors

CURRENT RATINGS

Size B. & S. or A.W.G.	Starting Duty		Intermittent		Continuous
	Light EPC-11 to 16	Heavy EPC-31 to 36	Light EPC-51 to 56	Heavy EPC-71 to 76	EPC-91 to 96
16	56	40	28	20	14
14	80	58	40	28	20
12	112	80	56	40	28
10	160	112	80	56	40
8	224	160	112	80	56
6	320	224	160	112	80
4	448	320	224	160	112
2	840	448	320	224	160
0	1,170	840	448	320	224
000	....	1,170	840	448	320

Values for continuous duty are in a geometrical progression with factor = $\sqrt{2}$ and are based on 30 deg. C. rise.

Intermittent duty values are obtained by multiplying the continuous duty ratings by factor = $\sqrt{4 \div T} = 1.4$, where T is time in minutes out of each 4 represented by the service classification.

breaker set high enough to hold in when the motor is started gives no protection against sustained overloads of moderate degree. Sometimes a mixed installation is used, such as a time element trip for one element and an instantaneous trip for the other element. The time element unit protects against sustained overloads, whereas the instantaneous trip unit protects against sudden faults or severe overloads. The two elements must have different current settings. Such an arrangement possesses considerable merit.

A shunt-trip attachment on the circuit breaker is sometimes useful as a means of disconnecting the power in an emergency, as in case of failure of the regular control to function properly. For instance, such a provision is desirable in connection with the man-trolley drive of a coal or ore bridge where faulty action of the regular control might lead to overtravel into the bumpers.

Many controllers incorporate some degree of overload protection. This may or may not suffice to serve exclusively. If a direct-current controller includes contactors that interrupt both the positive and negative lines and if overload relay coils are provided in each line, the protection is complete. No motor cutout is then necessary, but it is desirable to have an unfused switch ahead of the controller in order to isolate the latter for adjustments or repairs. Many of the larger and more complex direct-current controllers are of this character.

Relatively few of the smaller standard controllers and starters include contactors in both sides of the line. Either fuses or a circuit breaker are required with such equipment in addition to the protection afforded by the controller. The latter is, therefore, more or less superfluous and a duplication. If a fused switch is used ahead of the controller the overload protection in the controller may serve to minimize the blowing of fuses. If a circuit breaker is used ahead of the controller the overload protection in the controller serves little or no useful purpose.

It is the writer's opinion that in general, direct-current controllers should afford complete protection and should be preceded by unfused knife switches, or else they should not incorporate over-current features; that is, circuit breakers should be installed ahead of the controller to serve the dual function of a disconnecting means and a protective device. This practice affords maximum simplicity. When thermal relays mounted directly on the motor are used, they may be considered supplementary to the current-actuated overload devices.

In the case of alternating-current controllers a different situation applies, as a multi-polar line contactor is generally used and this may readily be arranged to disconnect all lines. It is the writer's opinion that, in general, low-voltage, alternating-current controllers should incorporate complete overload protection and that only an unfused disconnecting switch should be provided immediately ahead of the controller.

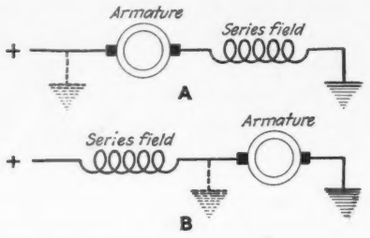

Fig. 8—These diagrams show, *A*, the proper and, *B*, the improper way to connect a series or compound-wound direct-current motor on a grounded system.

The dotted lines indicate the normal location of a flashover to ground. When connected as shown in *A*, the series field will not be energized if a flashover occurs. It will be seen in *B* that in the event of a flashover, the armature will be short-circuited in a strong field, which will cause a powerful braking action.

For voltages above 550 an oil circuit breaker may be installed in advance of the controller, or disconnecting switches may be used, or both. If the controller has sufficient rupturing capacity to enable it to handle a short-circuit the overload protection may be incorporated as a function of the controller itself. In this event disconnecting switches installed ahead of the controller will suffice as a means to isolate the controller for adjustment or repairs. If the controller has not sufficient rupturing capacity to handle a short-circuit an oil circuit breaker having proper rupturing capacity should be installed in advance of the controller. The overload protection should function in connection with the oil switch and not in connection with the controller.

Controllers should, in general, incorporate under-voltage protection to insure that in case of failure and re-establishment of voltage the motor will be started only by intention and in the proper manner. Under-voltage release should be substituted where controllers respond to automatic master devices such as pressure regulators, and so on. Reverse-phase protection is recommended for polyphase motors operating certain elevators, cranes, hoists and similar machinery where accidental reversal of rotation would be dangerous.

It is well to provide, in connection with the control, some type of "safe" button or lock (other than exposed switches) by means of which operators and repair men can prevent starting when they are working on the machine, or when it is not in running condition. Metal tags with the workman's number and a snap by which it can be attached to the switch or controller are useful in helping a repairman to prevent someone from acting unwittingly. This scheme protects machinery as well as men, as damage is often done by an electrician or other workman starting a machine that may be partially dismantled for repairs.

It is desirable that both alternating- and direct-current motors be operated upon circuits that are free from grounds. Continuity of service can be better assured if a single ground does not necessarily and immediately put a motor or controller out of commission. When it is necessary to operate upon grounded circuits suitable precautions should be taken, as a ground at an inopportune point in the main or pilot circuits may cause false action of the control. The provision of emergency trips for line contactors or line circuit breakers may be advisable where an overtravel would be serious.

In connecting a series- or compound-wound motor on a grounded system, it is advisable to connect the series field on the grounded side of the armature as shown in Fig. 8 *A*. If the series field is connected ahead of the armature, as in Fig. 8 *B*, and the motor flashes from a brush to ground, the armature is short-circuited in a strong field. The motor then acts as a short-circuited generator, causing a severe braking action with possible mechanical damage. On the other hand, if the series field is connected on the grounded side of the armature, Fig. 8 *A*, this difficulty is obviated, as the field is not energized from the line when the motor flashes over. This mode of connection also reduces the stress between the series field coils and the frame of the motor.

These views show the effect of cleaning the skylights in a factory. At the left is the photograph of a factory interior lighted by natural daylight through dirty skylights and poor artificial illumination. The view at the right shows the same interior after the skylights were cleaned. No artificial light was used.

Cost of Daylight Illumination

in Industrial Plants

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THE problem of economically lighting indoor work-places should include a study of the cost of both natural and artificial lighting. Ordinarily both systems of lighting are provided in buildings, but too little attention is given to their relative costs and utility. Natural daylight indoors costs as much as and in many cases more than artificial lighting and is available only during a relatively few hours of the 24-hr. period.

Records at the Cleveland office of the United States Weather Bureau show that in the past 29 years Cleveland has had an average of 6.2 hours of sunshine, 6 hours of cloudiness and 11.8 hours of darkness in the 24-hr. period. The seasonal variations of these periods are shown in graphic form in Fig. 1. These data are indicative of the relative hours of sunshine, cloudiness, and darkness during the 24-hr. period, but do not directly indicate the hours that artificial lighting is necessary, because natural daylight indoors is considered inadequate when the intensity of illumination outdoors is still relatively high. From the viewpoint of our indoor activities, darkness comes much sooner there than it does outdoors.

Several years ago, A. Smirnoff[1] made a study of the influence of the variations in daylight intensities on the use of artificial light in Washington, D. C. In this city manufacturing is a small part of the central-station load and the supply of electrical energy for the business district is independent of that for the residential district. These conditions enabled Mr. Smirnoff to compare readily the variations in current demand on the central station with daylight intensities. The data collected serve as an indication of the influence of daylight illumination intensities on the use of artificial lighting. He found that there was a definite increase in the consumption of electrical energy when the records of the Weather Bureau in the city showed that the total daylight (at a point where the entire sky was visible) decreased below 1,500 foot-candles. As the intensity of daylight illumination outdoors in an unobstructed location decreased below this value, the current consumption sharply increased, but all variations in outdoor daylight illumination above 1,800 foot-candles had only a very small influence.

Some of these data are reproduced in Fig. 1, where it is interesting to note the general uniformity of the current consumption on a clear day, July 25, with that for July 29, when it became quite cloudy in the afternoon. The dotted curve below the two ampere-demand curves in Fig. 1 represents the variation in total daylight illumination on a

[1] Influence of Daylight Illumination Intensity on Electric Current Used for Lighting Purposes in the District of Columbia, A. Smirnoff, *Trans. I. E. S.* Vol. 18, No. 1, 1923.

horizontal surface in the open on July 29. The horizontal broken line at 1,500 foot-candles indicates the level of outdoor illumination at which daylight becomes inadequate in some portions of the indoors which have been depending on natural light. The intensity of illumination outdoors at which daylight begins to fail indoors varies somewhat for various interiors depending upon the exposure, visible sky area, and so on.

When the 1,500 foot-candle point was reached in the open in Washington, it was found that the illumination at a certain west window was 360 foot-candles, but it was only 9 foot-candles 6 ft. away from it. Assuming that the worker resorts to artificial lighting when daylight illumination indoors reaches 2 foot-candles on the average, one concludes that the maximum average daylight illumination indoors is about 10 foot-candles. This value coincides fairly well with general experience. Thus it is seen that average illumination intensities of daylight indoors in our congested cities are not high. In fact, they average less than 1 per cent of the outdoor intensities.

Indoor daylight not only varies with the variation of outdoor daylight, but the quantity of it depends upon the exposure, glass area, location of openings above the ground, adjacent buildings and other things which restrict or obstruct the entrance of light from the sky. From the viewpoint of uniform distribution of light over the floor or other horizontal planes, overhead skylights are generally superior to windows in the walls. However, the use of skylights limits the buildings to one-story construction, or involves the use of light-courts.

Inasmuch as skylights are overhead, they are out of the direct visual field, whereas windows are often in the visual field and are commonly sources of glare and visual discomfort amid the relatively dark walls of interiors. From almost every angle, natural lighting indoors, by means of windows, is unsatisfactory when one considers it in terms of outdoor daylight or of what can be done with artificial light.

The daylight equipment in most factories represents an appreciable investment from which the maximum return is not obtained unless the glass is kept reasonably clean. Data supplied by the management of a factory are presented herewith to show the gain resulting from the cleaning of skylights.

COST OF CLEANING SKYLIGHTS

Cleaning compound	$30
Labor (11 days)	66
Total cost for 6,000 sq.ft.	$96
Cost per sq.ft.	$0.016

VALUE OF CLEANING

Saving in artificial lighting per day	$0.60
Increase (5 per cent) in labor efficiency	13.75
Saving per day	$14.35
Saving per month	$358.75
Increase in profit on extra production	(not given)
Saving due to better inspection	(not given)

The saving in labor cost represented in an increase of 5 per cent in labor efficiency in one week paid for the cleaning without taking into consideration the profit on the extra production, the value of better inspection, and other factors[3]. The management stated that "one of the main reasons for cleaning the skylight was that it added greatly to the general appearance of the plant. This alone is worth the expense required." The effect of cleaning skylights in a factory is shown in the illustration at the head of this article. The photographs are of the same interior illuminated first by natural daylight through dirty skylights and poor artificial lighting, and then illuminated only by natural daylight through clean skylights.

Without considering cost, the ideal system of lighting designed wholly from the viewpoint of the greatest certainty, speed, safety, and comfort in human activity should provide an illumination intensity of hundreds of foot-candles. Natural daylight of such intensities cannot be provided in workplaces continuously; therefore, artificial lighting must be provided for the periods when daylight fails. Artificial lighting is available throughout the 24-hr. period and the relative outlay for natural and artificial lighting for interiors should be a function of their relative utility.

Many computations have shown that daylight from windows, with all its failings, costs fully as much as good artificial lighting. The chief items that contribute to the initial net cost of natural lighting equipment are:

(*1*) The difference in the cost of the building with and without windows and skylights.

(*2*) The ground areas sacrificed for light courts and in other ways to obtain effective daylight openings.

(*3*) The cost of the extra capacity in the heating system required to supply the excess heat losses from the glass area over those incurred

[3] "Light and Work," by M. Luckiesh, D. Van Nostrand Co., New York, N. Y.

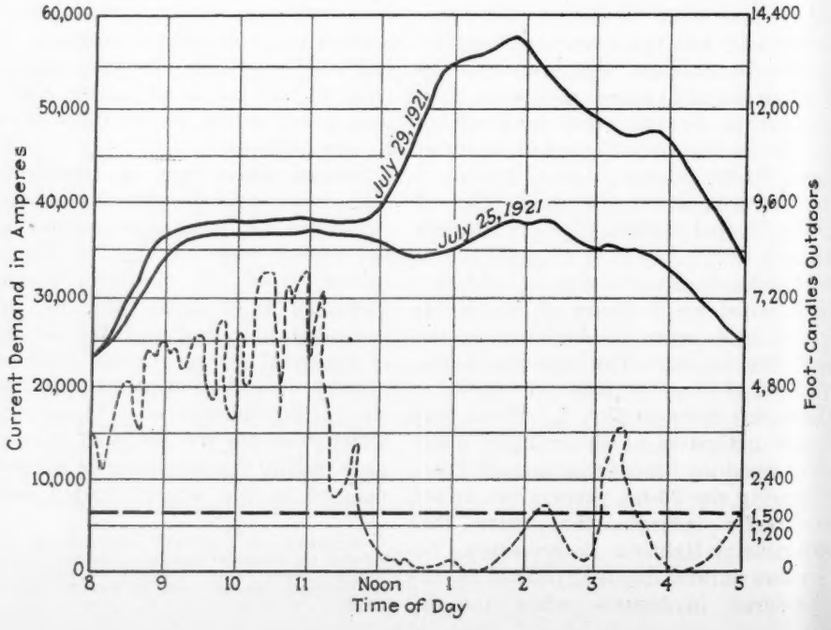

Fig. 1—Comparison of current demand for the business section of Washington, D. C., with daylight intensities.

These curves show the influence of cloudiness on the amount of current used for artificial lighting. The dotted line curve represents the daylight illumination intensity outdoors (right-hand scale) on a horizontal surface exposed to direct sunlight and the entire sky on July 29. The broken horizontal line, representing 1,500 foot-candles, indicates the level of outdoor illumination at which daylight is no longer sufficient for some indoor locations.

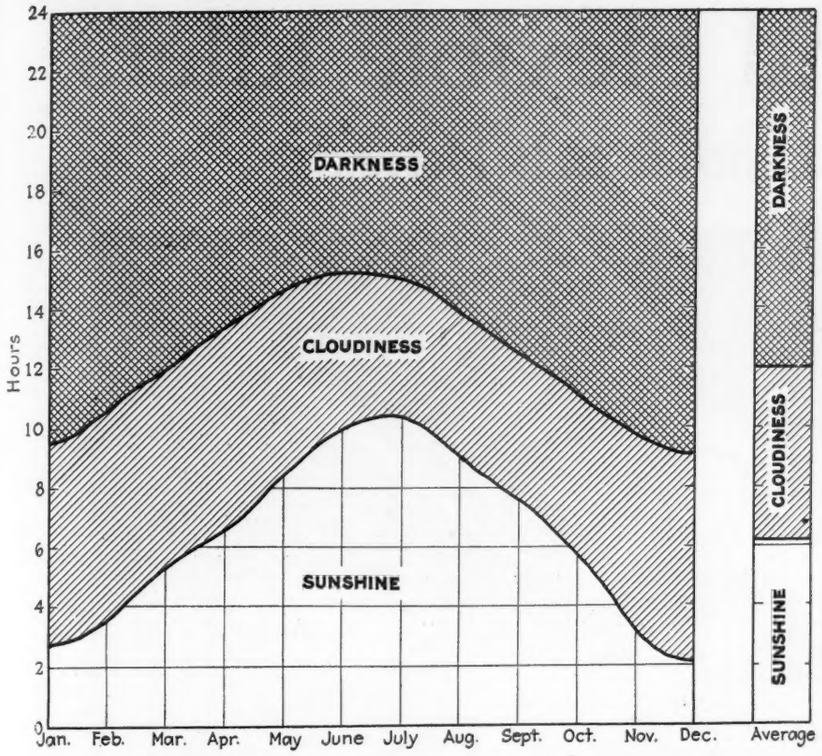

Fig. 2—Average variation in hours of sunshine, cloudiness, and darkness during the 24-hr. period at Cleveland, Ohio.

These data represent a summary of the records compiled over a period of 29 years.

with walls, ceilings, and so on of equal size.

The chief items that contribute to the operating cost of natural lighting equipment are:

(*1*) Interest on initial net investment.

(*2*) Depreciation on natural lighting equipment.

(*3*) Repairs.

(*4*) Cleaning glass.

(*5*) Depreciation of extra heating system.

(*6*) Extra fuel.

There are a number of other items that may be charged to natural lighting but they are largely a matter of judgment, such as window shades, spoilage due to dust and leaks, fading of materials, sacrifice of floor space and wall areas, and cost of artificial lighting used during the natural lighting period when daylight is inadequate.

In many cases daylight indoors is inadequate and the investment in natural lighting equipment is not paying dividends. Inasmuch as artificial lighting installations are necessary in most places, it would be an economic measure in many cases to divert the outlay required for inadequate and undependable daylight illumination to the installation of an excellent artificial lighting system. We recognize the psychological effect of the absence of windows, but in congested cities men are now working under inadequate natural lighting reinforced by artificial lighting—one of the least satisfactory lighting conditions. Others are required to work all day under a total absence of daylight. Our complex civilization demands the services of thousands of night workers who get along without daylight. We are bound by habit and do not readily adapt ourselves to the requirements of the new era.

We want daylight where we can obtain it in adequate amounts and at a reasonable cost, but we should recognize its cost and shortcomings. Our complex city life calls for many compromises, and in many industries the psychological advantages of natural daylight and windows will be outweighed by the economic advantages of artificial lighting. The economies of lighting indicate that we are at a turning point. In the new era, which is before us, natural lighting in many places is bound to give way to artificial lighting, because of the great handicaps imposed upon it by indoor civilization.

The designers, builders, owners, and operators of buildings should not be guided solely by habit. The problem of day-lighting interiors should be carefully studied in this era of decreasing cost of controllable artificial light and increasing cost of daylight.

The question of ventilation naturally arises in connection with any proposal to lessen our dependence on daylight illumination. The answer is that ventilation is a growing art which, like artificial lighting, can stand firmly upon its own merits. It does not need to be an adjunct to natural lighting. Ventilating and heating can best be provided for by not having to contend with the uncertainty introduced by the haphazard opening or closing of windows.

Wedge Tool Simplifies the Rewinding of Armatures

A HANDY tool for use in winding armatures or stators having open slots in which fiber retaining wedges are employed, and where the winding cell used has its upper ends turned over on top of the coil, may be made from a piece of flat, cold-rolled steel, 1x¼ in., one end being turned up and pointed as shown in Fig. 1. The pointed end is tapered and both edges are beveled, so as to fit into the wedge groove in the teeth.

The tool is used as follows: After all coils are in, trim the cells so that the ends just meet in the center of

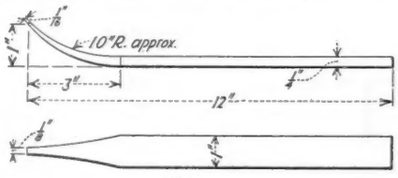

FIG. 1

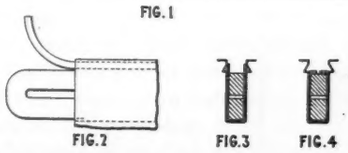

FIG. 2 FIG. 3 FIG. 4

This wedge tool eliminates the necessity of using fiber drifts when rewinding open-slot armatures or stators.

the slot. Then with one finger of the left hand press the ends of the cells down against the coil, pushing this tool down on the bent corner of the cell, and at the same time insert it into the slot until it binds in the wedge grooves. Work the tool sideways, as this side motion opens the ends of the wedge groove and allows the wedge to start easier. Also, the bottom of the tool starts a bend in both sides of the cell, a short distance into the slot, so that when the wedge is driven into the slot it also bends the cell ahead of the wedge.

Fixed and Flexible Idlers

On Leather Belt Drives

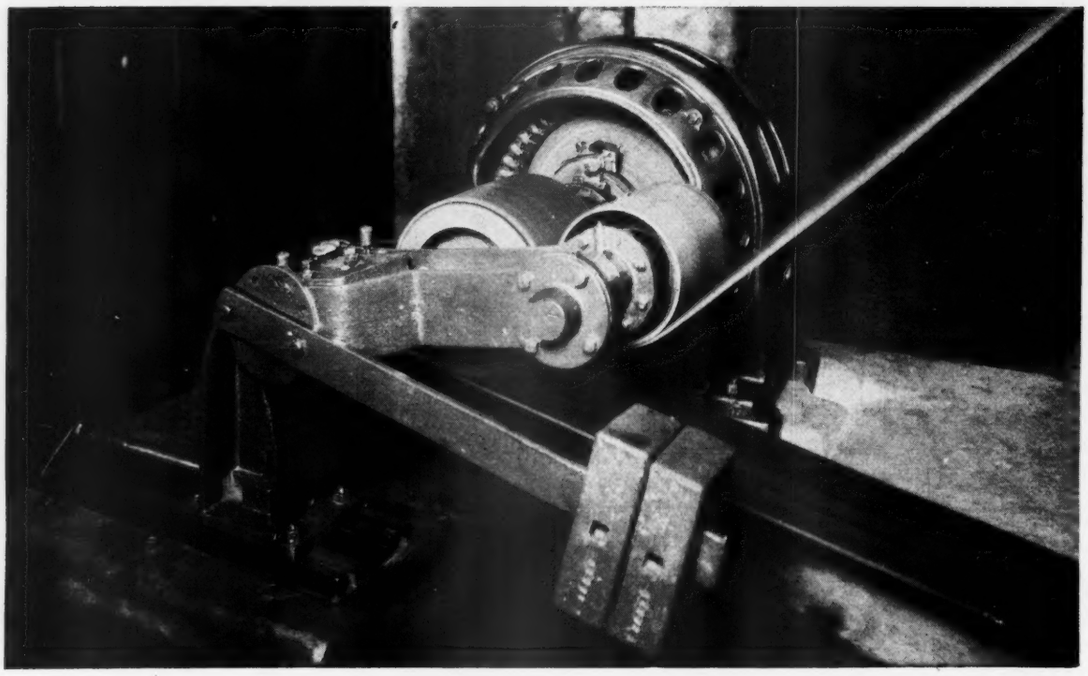

Fig. 1—Note the steadiness of the idler on this belt, transmitting 75 hp. to an ice machine. This steadiness results from using properly balanced pulleys and correctly designing the drive. The idler is on a slide base which permits it to be moved with the motor to take up belt stretch.

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THE article entitled, "Determining Center Distances for Leather Belt Drives," which appeared in the May issue of INDUSTRIAL ENGINEER, discussed some of the factors that must be taken into consideration when determining the proper center distance to use in order to obtain good operating conditions.

One of these factors is a satisfactory arc of contact on both pulleys of an open belt drive when it is necessary to place them some distance apart. This consideration brings up two objectionable features, particularly on drives where there is considerable difference in the pulley diameters; namely, the pulleys have to be placed a considerable distance apart, which makes the drive occupy considerable floor space; also, with increased center distance, the effect of the sag from stretch and the flap from vibration are more noticable.

In that article reference was made to the short-center belt drive through the use of the flexible or gravity idler. One of the sketches in that article indicated the space-saving feature of such drives. Obviously, the combination of a short center distance and having both strands of the belt tight would overcome the flap, and with decreased length the amount of stretch would be less.

Many operating men have a very strong prejudice, however, against the use of idlers in any form because of troubles they have had with extremely short-lived belts and excessive belt stretch on this type of drive. These troubles have been largely due to faulty layout of the drives and the use of belts unsuited to this type of drive. When idler drives are laid out properly and equipped with suitable belts, not only is the belt life as long as that of an open drive but the maintenance and cost of operation are considerably less. This is because drives equipped with the proper idlers automatically care for themselves under all kinds of loads.

The two most commonly used types of idlers are the fixed and the flexible or gravity idlers. *A fixed idler is suited only to those drives on which the small pulley is the driven pulley and the load is more or less steady; that is, it does not fluctuate.* The average generator drive is an example of such a load. In these cases the idler should always be placed as close as possible to the smaller driven pulley and on the slack side of the belt. Its location should be such as to make the wrap or arc of contact on the small pulley approximately 225 to 245 deg. The sketch in Fig. 2*A* shows a typical installation of a fixed idler.

When the idler is in this position the belt can be run fairly slack. The tension on the small pulley, however, is maintained by the checking effort of the idler on the belt as the belt bends around the idler. On such drives it is necessary to use a belt amply wide for the load it is to transmit and the diameter of the small pulley must be in proportion to the load transmitted over it. The next article of this series will contain a table listing proper pulley diameters for various loads. The maximum effective tension for a belt operating

on such a drive should not be over 250 lb. per sq.in. of cross-sectional area.

The most common type of adjustable idler, and the one best suited for all conditions, is the flexible idler, typified by the Lenix and Pulmax drives, and other similar units. These consist of a pulley mounted on a swinging and weighted arm which can be set to give a direct tension, but is self-adjusting to meet load variations. Some of these drives are shown in the accompanying illustrations. The flexible idler should always be located next to the small pulley (regardless of whether it is driving or driven) and on the slack side of the belt. The clearance between the faces of the two pulleys should not be more than 1 to 1½ in. when they are in their closest position, as shown in Fig. 2*A*.

Never place a flexible idler midway between the two pulleys or next to the larger pulley if it can be avoided. When either the fixed or the flexible idler is placed midway between the two pulleys it makes a drive which is nothing more than a good belt stretcher, because the idler can move through a considerable distance and take up only a small percentage of the stretch in the belt. Also, it does not increase the wrapping or arc of contact of the belt on the pulley.

This is easily seen by a comparison of Figs. 2*A* and 2*B*. As was explained in the previous article, the belt drive which will operate with the least number of cuttings to remove the stretch or, in other words, accumulates the largest percentage of stretch between cuttings will require the least maintenance. This operating characteristic is of considerable importance because the user generally judges a belt by the cost of maintenance and the frequency with which it requires attention.

When the idler is located midway between the two pulleys the operator invariably places more tension on the belt than he realizes, with the result that the belt stretches excessively and he finds it necessary to make frequent take-ups. When the idler is placed next to the larger pulley the arc of contact on the small pulley, where it is most needed, seldom amounts to more than 180 deg.

This condition is very commonly found on compressor drives where the idler is attached to the machine and the motor is often located a considerable distance away.

Figs. 3*A* and 3*B* show the results of having the motor located close to and also at a considerable distance from the idler. It is very noticeable that the arc of contact is greater when the idler and the small or motor pulley are placed close together than when they are located a considerable distance apart. With longer center distances the belt wrap is not increased much by the idler.

This same condition would hold true even though the pulley center distance in Fig. 3*A* were increased to equal that shown in Fig. 3*B*, providing that the idler was kept in the same relative position close to the small pulley.

With the use of a properly designed and balanced flexible idler, it is possible to use extremely short centers but it is not advisable to do so unless proper precautions are taken. Extremely short centers make a very rigid belt because there is not enough length in the slack strand to allow the belt to contract properly. The result is a short life for the belt. It has been found from experience that where enough length is allowed between pulleys so that the slack strand of the belt is long enough to allow a certain amount of spring or stretch, the life of the belt is very much longer and the whole layout operates with greater satisfaction.

Belts, like many other materials, cannot remain under continuously high tension without their fibers breaking from fatigue. Where moderate centers are used, the fibers in that part of the belt on the slack strand are able to recuperate with the result that the fibers over the whole belt are not continuously taut and do not become fatigued as rapidly; consequently, the life of the

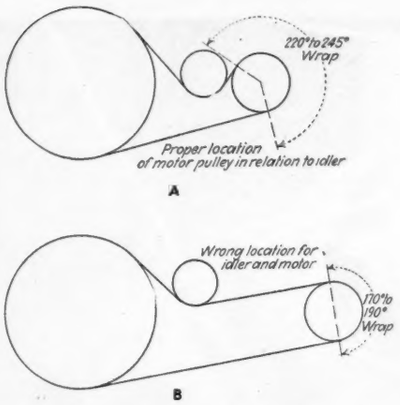
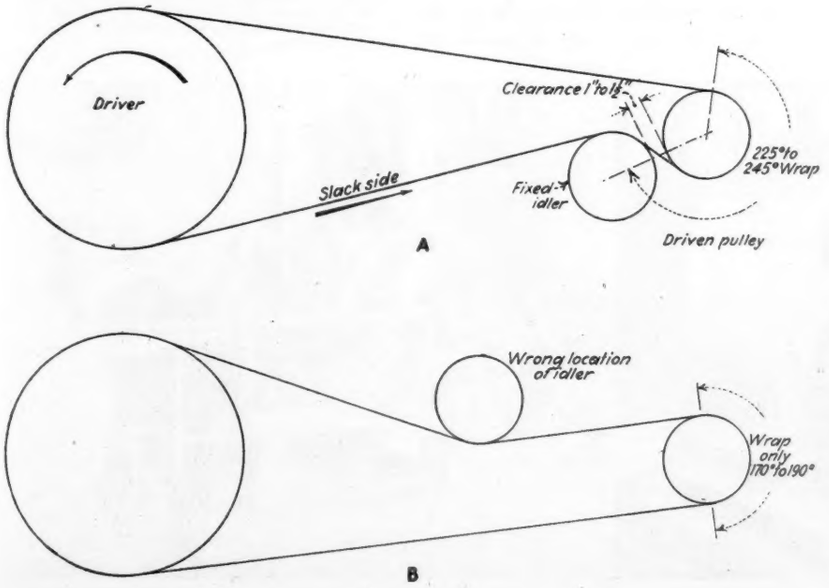


Fig. 3 — Compressor drives frequently have the idler mounted on the compressor unit.

In such cases the most satisfactory drive results when the motor is mounted close to the compressor, as in *A*. This gives ample belt wrap on the smaller driving pulley where the larger arc of contact is necessary. With longer center distances, as in *B*, which shows the wrong method of installation, the belt wrap is not increased much by the idler. It must be remembered that it is on the small pulley that the additional belt wrap is needed and so the position of the idler should be considered in relation to the small pulley.

Fig. 2—Proper and improper locations of a fixed idler on belt drives.

Fixed idlers should be used only when the small pulley is the driven pulley. When properly located on the slack side of the belt, as in *A*, adjusting the idler up or down will take care of belt stretch. It is especially important that sufficient clearance be maintained between the idler and the pulley and that the idler be without crown. Thin, pliable leather belts, made endless, give the best service. Placing the idler at some distance from the smaller pulley, as at *B*, requires considerable travel or take-up of the idler to care for belt stretch. In addition, this location results in excessive strain on the belt without materially increasing the effective tension, as such a drive will give only from 170 deg. to 190 deg. of belt wrap.



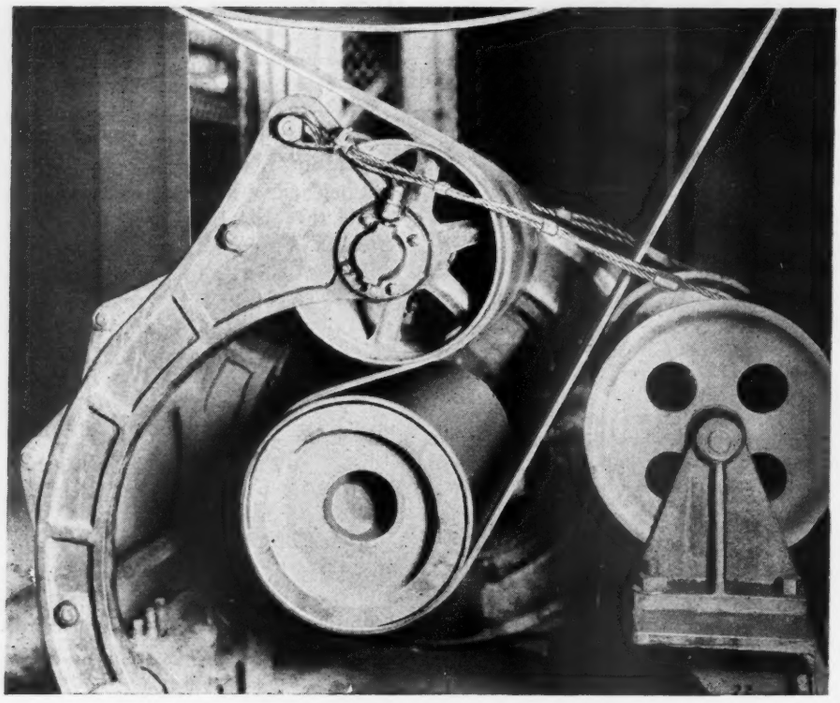


Fig. 4—Pressure is applied to the idler through a weighted cable over a sheave.

Sometimes, on vertical or other types of drives, a cable and sheave are used instead of a lever to maintain the proper contact between the idler pulley and the belt. This Pulmax drive operates a 90-kw. generator from a water-wheel-driven jackshaft. Because of the high reduction obtainable it was possible to use a 900-r.p.m. generator instead of a more expensive 600-r.p.m. unit. In addition, 30 ft. of lineshaft and considerably less belting were necessary. The reduction is from a 100-in. driving pulley to a 16½-in. driven pulley, with pulley centers of 7. ft.

belt is considerably longer. Wherever it is necessary to use extremely short centers, wider belts should preferably be specified to make the effective tension in the tight strand considerably lower. Tensions as low as 200 and never over 250 lb. per sq.in. of cross-section are recommended to insure long life for belts.

The idler pulley should always be flat-faced and should never have a crown. Also, it should be well balanced for the speed at which it is to operate. Oftentimes an idler pulley, although balanced statically, is found to be badly out of balance dynamically and causes vibration or chatter. This, of course, eventually offects the alignment of the drive and is also very hard on the bearings.

The bearings used in these idlers should be of the best quality and special attention should be given to oiling them. Usually, after an idler has been installed the bearings receive very little attention even though the motor, compressor, or other bearings may be oiled frequently. Carelessness in failing to oil the idler bearings is largely due to the fact that the operator feels that the idler is doing very little work and requires practically no attention. It must be remembered that the weight maintains a fixed pressure on the bearings, which necessitates providing the proper lubrication, even though the pulley does no work.

The best method of maintaining the proper tension in a belt, where a flexible idler is used, is by means of weights applied either directly or through the use of cables and pulleys when necessary. These methods of applying the weights are shown in some of the illustrations.

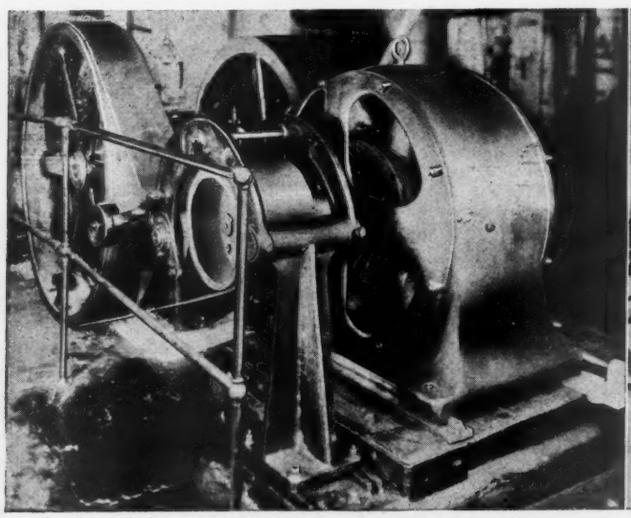
Springs are sometimes used, but they are seldom satisfactory because a spring applies the least amount of tension to a belt at the time it needs the most. When a belt is under the heaviest load it elongates, due to the elasticity of the fiber, and, when it is elongated, the springs forcing the idler against the belt are under the least tension. It is while the belt is under the heaviest load that it needs the most tension in the slack strand. Weighted idlers are, therefore, more

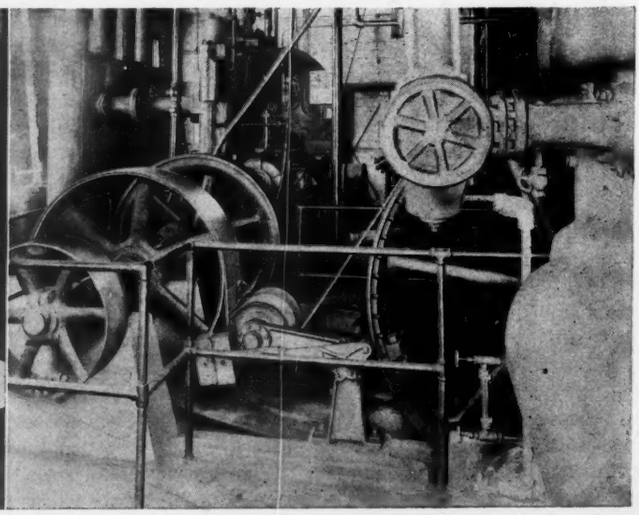
Fig. 5—The belt on this drive lasted 18 years.

Belt drives that are properly laid out give long life and economical operation. Furthermore, the first cost of a well-designed belt drive is little more, and sometimes less, than that of an incorrectly arranged layout. Here both the generator and the idler are on slides to permit take-up and compensate for belt stretch.

Fig. 6—An 11-in. double belt is used on this 60-hp. engine-driven air compressor.

The belt operates at 3,300 f.p.m. on 7-ft. centers. The gas engine and the air compressor impose a shock load on both driving and driven ends of the belt. Because of the flexible-idler drive much of this is compensated for and absorbed by the weight on the idler pulley.





satisfactory and when they are used the life of the belt will not only be longer but the whole drive will require less attention.

Various engineers have different opinions as to what tension should be used in the slack strand of the belt. They determine the amount of tension to use in any particular installation from their experience. Engineers who have adapted flexible idlers to all sorts of drives find that, although they use certain fundamental rules, an idler drive should be laid out so that the tension can be adjusted after the belt is in operation by shifting or varying the amount of the weight. In other words, it can be observed from the manner in which the idler acts whether tension should be removed or added to make the drive perform properly under all loads which the belt must carry. Industrial men in charge of power transmission should aim to operate the idlers under a minimum amount of tension so as to increase the belt life, and still be sure they have enough weight on the idler so that it can carry any peak load the belt may be called upon to handle.

Where the load is very steady, the pulleys properly proportioned for the load to be transmitted over them, and the width of the belt is suitable, the weight of the idler at the point where it bears upon the belt is such that the ratio betwen the slack and tight strands may be approximately 1 : 7. However, where any one condition is not conservative, such as too small pulleys, belt not wide enough, short centers, or high peak loads, this ratio may then be reduced to 1 : 3, and the idler so constructed that weight can be either added or taken away in accordance with the observation of the belt's action while under load.

Wherever the load is irregular, it is advisable to put a short check-strap on the idler to keep it from jumping. For this purpose a short cable with a spring in it or hydraulic checks are often used.

Where belts are operating on suitable idler drives and are made for this type of service it is not uncommon for them to be in operation after 10 yr. of service. The secret of long belt life on a flexible idler drive is pliability of the belt and use of a correctly designed, balanced idler. If the belt is stiff it will wear out prematurely. After being tanned, the leather used in the manufacture of high-grade belting is thoroughly scoured to remove the grit that has penetrated into the fiber during the tanning process. This is followed by a thorough currying with animal greases to make the leather very pliable; such treatment adds years to the life of the belt leather.

Belts operating on drives where the total tension in the tight strand is as high as 350 lb. per sq.in. have a very short life. On the other hand, belts that are operating where the tension in the tight strand is as low as 250 lb. per sq.in. or less have a very long life. It is also very important that the diameter of the smaller pulley over which the load is to be transmitted be in accordance with the figures that will be listed in a table in the next article of this series, covering pulley diameters for various horsepower loads, to appear in an early issue.

If any unusual conditions are encountered in the laying out of short-center belt drives, the belt user will find it to his advantage to refer all data regarding pulley diameters, belt speeds, centers, peak loads, and belt widths to the engineering department of the belt manufacturer, who will make recommendations regarding necessary belt tensions and the arrangements of the drive so as to obtain the best results. Such procedure also costs less in the end.

The Selection of a Welding Process

A PAPER by L. E. Everett, research engineer, the Nugent Steel Castings Co., Chicago, Ill., under the above title, was presented at a recent convention of the International Acetylene Association at the Congress Hotel, Chicago, Ill., and discussed the welding problems at the plant with which the author is associated, and the points governing the selection of the method of welding best suited for each type of work. Mr. Everett stated that welding is used to repair minor defects which affect the appearance but not the strength of the casting. Some of the defects that necessitate welding, and their causes, are as follows: dirt spots, sand spots, slag spots, scabs, shrink cavities, blowholes, and cracks. In addition, welding is sometimes used to fill in the casting where the risers, heads, or gates are broken off beneath the surface of the casting. Finished surfaces which are ground too low are also sometimes built up by welding.

In general, when deciding whether to weld a defective casting or to scrap it, the decision is made on the following basis: If the defective area is small and in a location where it has little effect on the strength of the casting, it is welded. If the defect is large and the cost of welding would exceed or even approach the cost of remaking the casting, or the strength and service value of the casting would depend largely upon the weld, the casting is remade. This decision is subject to the approval of the inspection standards set up by the Electric Steel Founders' Group. The method of welding used and the basis for deciding which method is preferable for any particular service, are given by the author as follows:

"Castings having minor defects that can be repaired by welding are marked up (that is, the defective areas are outlined with chalk) and the inspector sends them to one of the welding units. We have equipment for welding by the following processes: (1) The bare metallic electrode process; (2) the carbon electrode process; and (3) the oxy-acetylene process.

"A chipping floor is arranged in conjunction with each welding unit and all defects to be repaired are first chipped out to clean, solid metal. In the majority of cases, where the weld is at all important, the chipping is passed on by the inspector before the casting is permitted to go to the welder. In this manner a base of sound metal is insured for the weld.

"In the selection of the repair process, the size of the casting, the size, character and location of the defect, and the type and application of the casting, all have a bearing. The cost and productive capabilities of the processes must also be considered. Let it be strictly understood here that we are making no claim for the superiority of one process over another. We merely indicate what our own experience, guided by our own research, has been and the application we make of these processes to our practice.

"Consider first the bare metallic electrode welding process. This is used in our plant to make small re-

pairs such as are made necessary by slag and sand spots, small blowholes, and so on. We also use this process on surfaces which are to be subjected to machining operations. Generally speaking, the application of the metallic electrode is confined to our smaller castings, and the smaller defects on the larger castings. We find welds made by this process to be well fused with the casting metal, and to be sufficiently strong, ductile, and soft, after the thorough treatment of the casting to be machinable, and apparently satisfactory.

"We find the greatest application of the carbon electrode process, or carbon arc welding as it is called, in welding the larger defects in the larger castings. Due to the propensity of the arc to deposit carbon in the weld metal, this process is seldom used on the surfaces of castings that are to be machined. We find this method to be the quickest and cheapest way of adding any appreciable amount of metal, and the welds are seemingly sound and sufficiently strong. In using this process, recourse is had to the scratch brush and the hammer, and satisfactory welds of fairly large size are comparatively quickly and cheaply made.

"The oxy-acetylene welding process is used largely in welding leaks in our pressure fittings, or elsewhere, when the strength of the weld and its soundness are of primary importance. In other words, when the weld passes the stage of appearance and the service capabilities are of prime importance this process is used. The oxy-acetylene process is used for this class of welding for several reasons: First, on account of the slightly reducing characteristics of the normal flame, less oxide inclusions and less slag are incorporated in the weld than with the arc processes. This yields a stronger, denser, cleaner weld with superior ductility. The second point is that welding for leaks or for serious defects in pressure fittings requires the best of workmanship, and it is very much easier to exercise close supervision over the gas welding than it is to do the same with either of the arc processes.

"In areas that are to be subjected to extremely close machining, and where perfect, sound surfaces must be maintained, such as valve seats, we find we can place greater dependence on the oxy-acetylene welds than we can on the arc product.

"Occasionally a weld must be made on a casting of the 'rush' variety, a break-down job, and after all the finishing operations, including heat-treatment, a defect unnoticed before is found. If the customer agrees, the defect can be oxy-acetylene welded and the re-heating treatment waived, as a perfectly sound, soft weld can be put in with the torch, and the stresses be sufficiently relieved by proper manipulation. This enables us to save the customer the delay which would otherwise be caused by the heat-treating operations and, withal, gives him a satisfactory casting.

"We find an occasional application of oxy-acetylene welding in our actual manufacturing and it has, at times, enabled us to produce castings at a considerably lower cost than would have been the case without it. I recall an instance where our facilities were inadequate for the manufacture of a certain casting. Through oxy-acetylene welding, which became for that particular time one of our major operations, we were enabled to complete the job satisfactorily and economically.

"The casting was a ring or reinforcing band, 90 in. in diameter, weighing about 300 lb., and the U-shaped cross-section provided for metal about ½-in. thick. We did not have a flask in the shop capable of taking this pattern, nor could we get the entire ring in our annealer, and it was neecssary that we either make a special flask and deliver the casting unannealed, or cast the ring in two halves and weld them together. We decided on the latter procedure and made several castings on the original order, joining the two halves with oxy-acetylene welding, and they were so acceptable that we have received repeat orders."

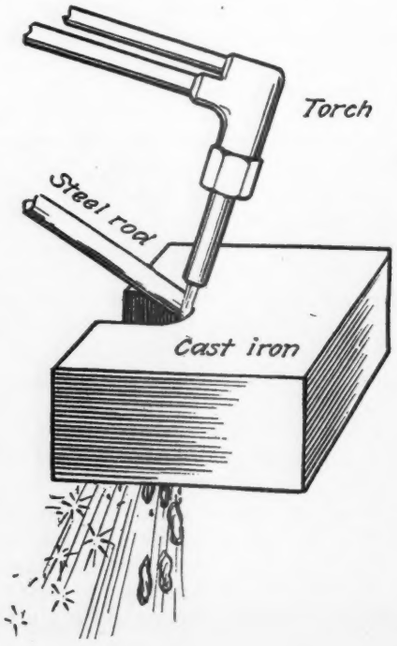
Cutting Cast Iron With an Oxy-Acetylene Torch

ASK the average welder if it is possible to cut cast iron and he will usually answer no when his answer should have been yes, according to the *Welding Engineer*.

Although cast iron cannot be cut as readily as steel, there are many instances where the operation will prove very satisfactory and highly profitable.

Since cutting cast iron is a hot job, the hands, face and body must be protected from the heat and heavy slag. Select a size larger tip than would be used in cutting steel of the same thickness. This tip should have a great preheating capacity.

A steel rod fed into the cut, under the torch, will wash out the molten cast iron.



Use a long carbonizing flame and hold the tip end about 2 in. away from the metal, so that the cutting jet of gas will be warmed before it strikes the metal. Incline the torch backwards and advance into the cut with a slight swinging motion in an arc about ¼ in. wide. Move the torch back and forth two or three times a second. If you strike a spot that will not melt or cut, follow it along to the edge of the black spot that appears until the flame takes hold again. Then the cut may be made around this spot.

The accompanying illustration shows a method of cutting cast iron which has proven very satisfactory. Simply feed into the cut a steel bar or welding rod about ¼ in. in diameter. The steel thus fed under the torch cuts readily and as it gives way it washes the molten cast iron free of the cut. The result is a cleaner, more narrow cut, and a decided reduction in time and consumption of gases.

Remember, however, that a higher oxygen pressure and consumption are required than in the cutting of steel. Do not be discouraged if the first attempt is not entirely successful, for the job can be done and it is comparatively easy to do once you acquire the knack of properly handling your torch.

Comparative Advantages of

A.C. and D.C. Motors for Crane Operation

By R. F. EMERSON
Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.

WHEN both alternating- and direct-current service are available in a plant the question sometimes arises as to whether induction or direct-current series motors should be used for crane operation. In some cases where both kinds of current are available, the operating conditions encountered on certain kinds of work may make it advisable to select one type or the other. Inasmuch as both alternating- and direct-current operated cranes are very satisfactory in service, either type chosen will be operative.

Comparing the advantages of one type of motor with the other, it is possible to obtain much finer speed control with a direct-current series motor than with an alternating-current motor. Referring to Fig. 1, curve *A* shows that speeds of less than 50 per cent of full-load speed can be obtained even at low torque values by using a shunted armature connection. Even greater stability can be obtained by adjusting the resistance in series and in parallel with the motor on this point of the controller. It will be seen that even at zero torque the motor will have a very stable speed, due to the flatness of this curve. In this same diagram curve *E*, which is obtained with dynamic braking, also indicates a very stable speed. When it is necessary for a crane to lower either a heavy load or a very light load slowly and carefully, it is seen that this can be accomplished very well, no matter whether the load overhauls the motor or whether motor torque is required to drive a light hook down.

Referring to Fig. 2, showing the characteristic curve of a slip-ring-type induction motor, it will be noted that at torques as low as 50 per cent the low-speed curve is very steep and no such nicety of control can be obtained as in the case of a direct-current motor with the control connections discussed above.

There are, however, means of obtaining a finer speed control with alternating-current motors, as, for example, putting an artificial load on the motor by means of a two-torque brake. It will be noted that at the high torque values on Fig. 2 the curves are flatter, and if a load can be put on the motor, a better speed control will be obtained. For use on the hoisting motion of the crane, there is the mechanical load brake, which is subject to wear and requires occasional adjustment, and the electrical load brake, which also provides for lowering heavy loads carefully and slowly, giving curves that approximate the dynamic braking curves with a direct-current motor. The electrical load brake, however, cannot be used on applications where there is a fast duty cycle.

The above comments are not intended to convey the impression that alternating-current motors cannot be used successfully on crane hoists, because there are a great many of them in service, doing excellent work. It is a fact, however, that the direct-current, rather than the alternating-current, motor is more adaptable for creeping speeds.

As regards torque, the induction motor has a definite torque beyond which it is impossible to go; further-

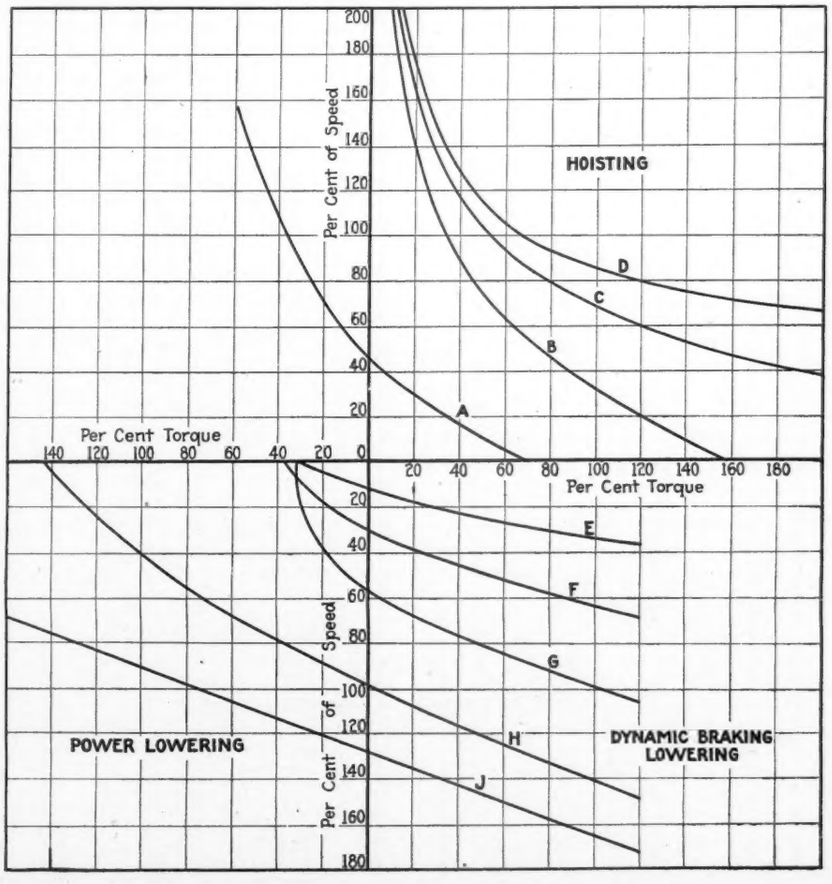


Fig. 1—Speed-torque curves of a direct-current, series motor.
By using a shunted armature connection speeds of less than 50 per cent of full-load speed are obtainable at low torque values.

more, this value is affected by low voltage. Referring to the above-mentioned torque-speed curves in Fig. 2, it will be noted that the maximum torque of this motor is 229 per cent, and irrespective of the amount of resistance in the secondary, it is impossible to exceed this value. It is, of course, possible, by putting in the correct amount of resistance, to cause the motor to exert its maximum torque at standstill. In the case of a direct-current series motor, it will continue to exert greater and greater torque as the controller is notched around, until the load is started.

Theoretically, the direct-current series motor will exert infinite torque at zero speed. As a matter of fact, the amount of torque it can exert is limited by its commutation and the amount of current its windings can handle without damage. If the voltage is low, the torque exerted by an induction motor decreases as the square of the voltage. In other words, if the voltage is 90 per cent of the normal value, the torque exerted will be but 81 per cent of what it would be at normal voltage. The direct-current, series motor is not affected in this way. Of course, this is an advantage if the crane is called upon to carry an extra-heavy load in an emergency. In such a case, the direct-current, series motor will probably be able to handle the load, whereas the induction motor will stall if the torque demand exceeds the maximum torque for which the motor is designed.

When a direct-current motor is used on a crane hoist, a descending load can be lowered slowly with good speed regulation, as mentioned above. In the case of an induction motor, if the controller is thrown to the reverse direction when a load is being lowered, the speed will go above synchronism by a few per cent and if resistance is cut into the secondary, it will cause the motor to overspeed instead of slowing down. Dynamic braking can be obtained with an induction motor, but this means exciting the windings by a source of direct-current power, which is usually not very convenient to do; furthermore, it complicates the control.

It is a well-known fact that when the load is reduced on a direct-current, series motor the speed will increase. In fast-duty cycle work, this enables the direct-current motor to work faster than an alternating-current motor. For example, if two bucket cranes are working, hoisting various loads and lowering empty buckets, the direct-current motor will speed up under light loads. Inasmuch as the induction motor is essentially a constant-speed machine, it will handle all loads at approximately the same speed. If it is to do the same amount of work as the direct-current motor, it will be necessary to gear the motor for a higher hoisting speed, when handling the average load, than in the case of a direct-current, series motor, so as to make up for the slower speed at which the induction must run when the direct-current motor is hoisting light loads. This means that the induction motor capacity would have to be greater.

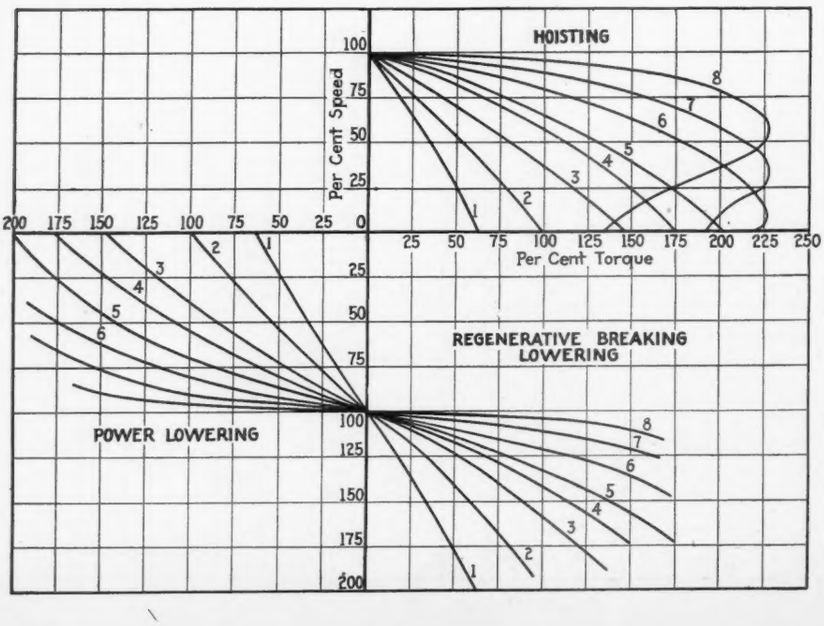


Fig. 2—Speed-torque curves of a slip-ring-type induction motor.
At the high torque values the curves are flatter; hence by putting an artificial load on the motor closer speed control can be obtained.

Without question the induction motor is a simpler machine, due to the absence of a commutator; consequently, the cost of maintenance will be less. This feature is, of course, a consideration in its favor. So far as drum controllers are concerned, there are probably no advantages of one control over another. So far as magnetic control is concerned, it is generally known that alternating-current contactors are noisier than direct-current contactors, due to their tendency to slam.

Inasmuch as the induction motor operates at nearly constant speed, it is comparatively easy to determine the speed reduction between the motor pinion and the crane wheels or the hoisting drum. It is only necessary to take the nameplate full-load speed rating and determine the crane or drum speed by the formula:

$$\text{Gear ratio} = R \times \pi \times D \div S$$

Where R = full-load speed of motor, in r.p.m.
D = diameter of drum to rope center, in feet.
S = speed of rope in feet per minute.

The rope speed on the hoist will vary within 5 per cent between full load and no load on the hook; hence the horsepower required for hoisting various loads is directly proportional to the load, with a maximum possible error of about 5 per cent.

If a similar method is followed with a direct-current, series motor, the speed obtained may not be at all satisfactory. The nameplate rating shown on a direct-current, series-wound crane motor is merely the speed at which the motor will run at its rated horsepower. However, the average load handled by the crane hoist will probably require considerably less horsepower than motor rating. If the motor is geared to hoist its specified load at the desired speed, on the basis of the motor nameplate speed, it will be found that the speed is considerably higher than expected, due to the fact that the series motor runs faster at any load less than its rated load. The correct method of calculating the drive is to obtain a speed-torque curve of the motor in question from the motor manufacturer and determine at what speed the motor will run at the proposed load; then figure the gear ratio, using the correct value for speed in the above formula.

Some of the Steel Mill Operating Problems

discussed at the annual convention of the Association of Iron and Steel Electrical Engineers

THE twenty-third annual convention of the Association of Iron and Steel Electrical Engineers which was held in connection with the Iron and Steel Exposition at Pittsburgh, Pa., during the week of June 13 to 18, was one of the most interesting and successful that has been held.

Approximately 150 manufacturers of steel mill and allied equipment demonstrated the latest devices that have been developed to cut operating and maintenance costs. These exhibits attracted much attention and were viewed by upwards of 20,000 visitors, it is estimated.

On the convention program there were six technical sessions, at which 15 papers and reports were presented and discussed. At the opening session on Monday morning the reports of the Electrical Heat and Electrical Development Committees were presented. The afternoon session was devoted to the symposium of the Safety Engineering Division.

The Tuesday morning session was given over to a symposium on antifriction bearings for heavy-duty steel mill application, in which five papers were presented. These were followed by a paper on the application of synchronous motors in steel mills.

Wednesday was Combustion Engineers Day. At the morning session two papers were presented. In one a recent boiler plant installation at the Edgar Thomson Works of the Carnegie Steel Co., was described by R. D. Abbiss, Special Engineer, of the Carnegie Steel Co. Following this paper, A. L. Foell, Chief Engineer, Donner Steel Co., discussed the flat, suspended, open-hearth roof.

The annual dinner and dance of the association were held Wednesday night at the Hotel Schenley.

On Thursday morning C. A. Menk, Electrical Superintendent, Carnegie Steel Co., Munhall, Pa., read a paper describing the electrical installation in the new structural mills of the Homestead Works of this company.

One of the most interesting features of the convention was the inspection trip to the Homestead Works, on Thursday afternoon, which was taken by more than a thousand visitors.

This inspection trip was made the occasion of a most unusual feat in the remote control of heavy electrical equipment, whereby Judge Elbert H. Gary, Chairman of the Board, United States Steel Corporation, started a 6,000-kw. motor-generator set by passing his hand three times over a large glass ball, while seated at his desk in the New York office of the corporation. This feat was made possible by the use of the Knowles grid-glow tube, recently developed in the laboratory of the Westinghouse Electric and Manufacturing Co., which is an extremely sensitive current controller. Impulses produced by Judge Gary passing his hand over the glass sphere, which was connected to the Knowles tube, were transmitted first by land wires and then by radio waves to the Homestead works, causing a gravity selector switch to operate. This in turn closed, through suitable relays, the control circuit for the motor-generator set.

Abstracts of the papers presented in the technical sessions, with the discussion on them, are given in the following pages.

Report of Electric Heat Committee

By GEORGE H. SCHAEFFER, Chairman

Electrical Engineer, The Carpenter Steel Co., Reading, Pa.

THE most important phase of electric heating to the steel mill man to date is melting. The various phases of this are given consideration first.

One of the principal factors of electric melting is speed, or time. In order to increase the speed or reduce the time of making a heat it has been found very advantageous to make use of three or more voltages. After cold-charging, according to the nature of the scrap, a hole is formed for each electrode with low or intermediate voltage for about 5 min. to smother the arc and save the refractories. The high voltage is then applied and kept on until the burden is semi-molten or the arc is no longer protected by the unmelted scrap. The intermediate voltage completes the melt, after which low voltage is used for the remainder of the heat.

The proper economic power input for a certain charge is still more or less of an open question. It is influenced by the cost of power balanced against production.

The most economical melting voltage for any particular job depends on the design of the furnace; that is, the diameter of the shell, height from bath to roof, and class of scrap. In a given furnace a higher voltage may be used with success on small, light scrap than can be used on heavy melting scrap such as crop ends, and so on. For plants where the power demands are taken only on the day load, it is sometimes advisable to use at night a melting-down voltage somewhat higher than the day melting-down voltage and thus take advantage of off-peak load.

With the application of higher melting voltages and higher power

input, heats are being turned out in 3 or 4 hr., power on to power off. With this shorter cycle the charging time becomes an appreciable part of the total tap-to-tap time.

High - Temperature Furnaces (Metallic-Resistor Type)—One of the most important applications of the high-temperature electrically heated furnace of the metallic-resistor type made during the past two years has been in the annealing of high-grade carbon alloy and high-speed steel bars. Within the past two years some 15 furnaces of varying capacities have been installed for this service. These furnaces are usually of the car-bottom type and, depending upon the type of steel, the bars may be loaded directly on the car for open annealing, or may be packed in boxes or tubes. Tool steel annealed under proper conditions in electric furnaces of this type has been practically free from scale and decarbonization.

The annealing cycle for this steel is usually long, ranging from 42 to 72 hr., depending upon the size of the charge and the physical requirements of the steel.

A battery of furnaces may be scheduled to operate in sequence and very economical use be made of the demand. For instance, a battery of three furnaces may operate on the equivalent of 1⅓ times the demand of one furnace.

The first electrically heated roll-treating furnace was noted about three years ago. The pit-type furnace with split covers is best suited for roll treating. These furnaces are improved models of the gun-treating furnaces used during the war, which were the original large industrial heat-treating furnaces of the electric type using metallic heating units.

Heat-treating furnaces range in size from small box units using a few kilowatts, for tool treating, to units 30 ft. wide by 50 ft. long having a connected load of 3,000 kw.

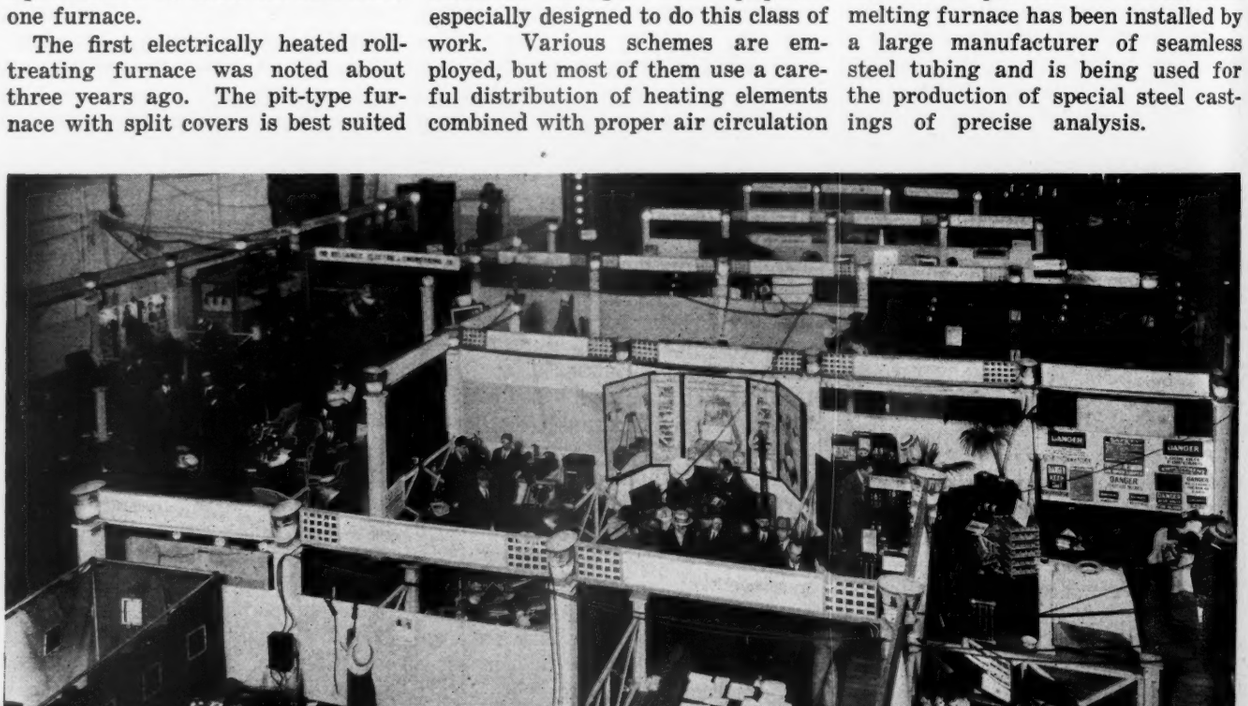
Pit-type furnaces having a depth of 40 ft. are now in operation. Prior to the disarmament conference, the United States Navy had contracted for a gun furnace 10 ft. in diameter by 105 ft. deep, and part of the material had been placed on the ground. Due to the abandonment of the Navy program the furnace was not completed.

Low-Temperature Furnaces (Air-Drawing, Tempering and Coloring)—For certain classes of steel products better working conditions can be obtained and a better product insured if the material is drawn, tempered and colored in an air bath rather than in salt, oil, water or lead. In order to do this the oven or furnace must have as nearly uniform a temperature throughout the entire working chamber as is possible. This has been approached, but never very successfully accomplished, until this past year when two or three manufacturers brought out equipment especially designed to do this class of work. Various schemes are employed, but most of them use a careful distribution of heating elements combined with proper air circulation to get uniform heat distribution. These units are being used quite successfully in a number of industries.

Miscellaneous Applications—There are now 164 roll heaters operating in the sheet and tin mills of 19 plants. Use of electric-roll heaters has increased first-turn production about one-third and decreased scrap loss by 10 per cent in these plants.

In addition to the foregoing, there are many applications for electric heat in the steel industry which today are common practice, such as local heating, as watchmen's shanties, crane cabs, isolated offices and the like. The main saving here is due to the elimination of waste and loss, such as condensation in steam pipes running any length. It is quite evident that electric heat has many advantages in such applications.

High-Frequency Furnace Developments—The past year has shown considerable progress in the field of high-frequency melting. Approximately 12,000 tons of copper-nickel have been melted by one company with a power consumption of approximately 430 kw.-hr. per ton. During this period one silver-melting furnace has been installed having a capacity of 1,000 lb. This furnace has been pouring between 1 and 4½ tons of silver per day, with a power consumption of 11 lb. per kw.-hr. or 182 kw.-hr. per ton. A 450-lb. steel melting furnace has been installed by a large manufacturer of seamless steel tubing and is being used for the production of special steel castings of precise analysis.



Report of Electrical Development Committee

By W. H. BURR, Chairman
Electrical Superintendent, Lukens Steel Co., Coatesville, Pa.

EACH year the problem of developing new equipment is given more serious consideration by electrical manufacturers, and naturally a larger financial investment is involved. In a report of this kind only such development as has reached a commercial stage is mentioned, which by the way is only a part of the best amount of development work, some of which may never be of any commercial value, carried on by manufacturers of electrical equipment. No effort has been made to cover any development that does not have a bearing on the application of electricity to the iron and steel and allied industries.

The information contained in this report was furnished by members of this committee; the writer's part has been simply classifying and compiling this information in such shape that it can be presented in the form of a report.

Main Roll Drives—It is interesting to note that 148 main-roll drives of over 300-hp. capacity were purchased during the year 1926. The past year has also witnessed the placing in service of an 8,000-hp., 40/80-r.p.m., 700-volt, single-unit reversing motor as a drive for a 54-in. blooming mill. This motor has the highest rated continuous torque of any mill drive yet built and has a maximum torque rating of 2,500,000 ft.lb.; in service, it has developed a torque considerably in excess of this amount. It is of exceptional interest in that it is of the single-armature construction, supplied with power from two 3,500-kw., 700-volt d.c. generators, connected in parallel. A simple method for the interconnection of the generator has been developed and perfected so that equal division of the load is assured, even under the most adverse conditions.

An interesting special installation of reversing-motor equipment is the application of two 7,000-hp., 50/120-r.p.m. motors on the edging rolls of the roughing and intermediate stands of a 52-in. universal structural mill. This is the first installation on record of separate reversing motor drives for the main and edging rolls of a universal mill.

On this same installation the screwdown control has been made with a number of automatic features. Limit switches are provided for each of the three screwdown motions, and the roll settings for each pass of the schedule are predetermined and set on these limit switches. The entire operation of the three screwdowns is then completely controlled from a single master switch which initiates the screwdown movements, the motions being accurately stopped at the predetermined positions by the limit switches. The use of these automatic features permit the operation of the mill with fewer men, and what is considerably more important, it assures the uniform drafting of the steel, and results in the production of a higher-quality product.

There has been unprecedented activity in the purchase and installation of the tandem type of continuous mills for the rolling of strip, merchant bar and rod products. One of these installations which has been in operation for about a year, is a 20-in.—16-in. strip mill in the Chicago district. A 10-in. tandem mill for the production of rod, merchant and strip products is now being installed in the St. Louis district. Developments in sheet steel rolling indicate that future installations will be along the line of continuous mills, especially for producing the heavier-gage material.

The development of continuous mills with individually-driven stands is responsible for the notable increase in the use of direct-current motors for main roll drives. Among new installations indicating this trend toward individual drive, there should be mentioned the 13-stand mill which will be installed by the Illinois Steel Co. at their South Chicago plant. This mill will be driven by 13 motors totaling 10,500 hp. At their Gary Works a 15-stand mill will have 11 motors totaling 6,500 hp., all of which are of the direct-current adjustable-speed type.

Another contribution during the last year toward the advancement in the art has been the installation of a 1,500-hp. synchronous motor direct-coupled to a 21-in. tube mill at Gary. This motor is started directly across the line and brings the mill up to speed, reverses, and has dynamic braking. In fact, it operates the mill in exactly the same way as was formerly done by a wound-rotor induction motor. This equipment has been in operation since the first week of January and has proved entirely satisfactory. This is simply another indication of the growing application of synchronous motors to drive steel mills.

Steel Mill Cranes—For a number of years there was very little development in steel-mill cranes, but within the last two years considerable work has been done along this line. The standardization of ball and roller bearings has opened up a new field in crane development. One manufacturer alone has in service over forty-five standard steel mill cranes, ranging from 5 to 40 tons capacity, which are equipped with roller bearings.

Another outstanding development during 1926 is the installation of numerous mercury-arc power rectifiers for substation operation, attended with great gains in efficiency, reduction in maintenance costs, and silence in operation. The total capacity of the power rectifiers already installed is approximately 50,000 kw.

One of the most notable advances in circuit breaker design during the past year has been the perfecting of the "non-closable on overload" feature to apply on air-break circuit breakers that are controlled from a remote point by means of an electromagnetic device. With this added feature it becomes impossible for a circuit breaker that is inadvertently closed upon an existing short circuit, or overload, to advance through the entire closing cycle. Immediately upon encountering an abnormal condition in the circuit, the contact-carrying members are mechanically tripped free, in order that they may return to the open position before the electrical equipment, or circuit breaker itself, may be damaged. This circuit breaker construction, which is known as the trip free at any point of the closing stroke, is proving of great value in both the industrial and in the public utility field.

Miscellaneous—Another new development during the past year, of

interest to steel mill electrical engineers, is the protection of switch contacts from the corrosive action of gases. This is accomplished by applying a special neutral alloy to the contacts and blades.

The conductivity of this alloy is only slightly less than that of copper and the contacts of switches are made slightly larger to compensate for this.

A noticeable advance involving a new principle developed by D. M. Simons of the Standard Underground Cable Co. is the machine-made joint on single-conductor cables operating at 60 kv. up to 132 kv., which has largely been responsible for the increased confidence of engineers in satisfactory operation of circuits at these higher voltages.

This information is given in the hope that it may in some manner be the means of reducing cost and increasing tonnage output, which after all is the goal for which all those connected with the steel industry are striving.

Safe Practices in Handling High-Tension Power

By A. N. CARTWRIGHT

General Superintendent, Power Division, West Penn Power Co., Pittsburgh, Pa.

THE subject of safe practices in the operation of high-tension power equipment is quite broad in its application, but for the subject of this paper I have brought it within the confines of the actual operation of the substation and the transmission lines connected thereto. The subject as a whole naturally divides itself into two main factors: safe practice with relation to the employee and to the public; and safe practice with relation to the apparatus and to the service. Some of the points brought out are very definite in their relation to the practices involving the human interest and other points are equally definite regarding the mechanical element, although in a very large measure, the two elements are correlated.

There must be station rules comprising well-thought-out simple orders applying to the individual station to govern the action of the operator in the event of loss of service to some or all of his equipment, and which will allow him to restore service, if possible, without the delay of getting into communication with the system operator or dispatcher.

The following are some of the general rules which in normal operation guard service and life:

(1) No high-voltage equipment may be removed from or returned to service during peak hours except by special permission.

(2) Advance notice required (usually 24 hours) to have high-voltage lines or equipment out of service to be worked upon and then such equipment must be removed from and restored to service during off-peak hours by the operating department.

This release card is one of the means employed to assure safety for the public and the employees.

Complete instructions for using this card are printed in black ink on a red background on the back of the card.

RELEASE ORDER

MEN AT WORK

Do Not Put Power On Lines Or Equipment Controlled By This Switch

DAY DATE 192

STATION

SWITCH

ORDERED OFF BY TITLE A. M. P. M.

SWITCH OPENED BY TIME

LINE GROUNDED AT A. M. P. M.

STATION TIME REMOVED A. M. P. M.

STATION TIME REMOVED A. M. P. M.

STATION TIME REMOVED

RELEASED TO A. M. P. M.

PERSON TIME A. M. P. M.

PERSON TIME A. M. P. M.

PERSON TIME

MEN REPORTED "CLEAR" A. M. P. M.

PERSON TIME A. M. P. M.

PERSON TIME A. M. P. M.

PERSON TIME A. M. P. M.

ORDERED ON BY TITLE A. M. P. M.

SWITCH CLOSED BY TIME

(3) Hourly inspection is required of all station galleries and switchyards by operators.

(4) Employees other than the operator and all visitors are refused admission to the high-voltage gallery or yards unless accompanied by the operator or properly appointed guard.

(5) Men working on lines and operators in station are required to report to nearest station or load dispatchers by telephone at least once per hour.

(6) Men working on steel structures on which high-voltage equipment is energized are required, whenever possible, to work from ladders rather than on the structure itself. This rule is made to eliminate the possibility of a man inadvertently going beyond the dead line established in connection with his work.

(7) Work is not permitted in two adjacent stations at the same time. This is to allow as much of the system to remain normal as possible and to minimize the effect of any trouble which may occur.

(8) Testing of all kinds is prohibited in generating stations and large-output substations during peak hours.

(9) No new construction, either in lines and apparatus, is put into operation until after it has been inspected in detail and approved by the system operating department.

(10) Routine patrol inspection of lines should be maintained, supplemented at regular and irregular intervals by trained special inspectors to pick up faults which the regular patrol inspector might not observe.

(11) A complete scheme of tagging is used to definitely call some particular condition to attention, to serve as a warning sign, to assist in checking operations, and to act as an instrument of record. Each of these tags has a definite color scheme with distinctive printing and is almost entirely self explanatory. The face of the tag indicates what use is to be made of the tag, and also the record spaces. The reverse side contains rather complete instructions for use.

Analysis is made of all operating errors and, if possible, rules are formulated to prevent their recurrence. Neglect of the rules or inexcusable mistakes are followed by dismissal or transfer to a less important position. In the general operation there is little that is theoretical; common sense for the most part is the solution of the problem.

Accident Elimination in the Operation of High-Tension Equipment

By T. E. HUGHES

General Foreman, Duquesne Works, Carnegie Steel Co., Duquesne, Pa.

THE problem of protecting electrical workers of the steel industry from hazards in the installation and maintenance of high-tension equipment is becoming more important each year.

A short time ago an analysis was made of the principal contributing causes of electrical industrial accidents and it was found that some phase of man-failure predominated in nearly every instance. In order to emphasize the conditions which exist, and which must be overcome among the men who are doing this dangerous class of work, it is desirable to review these causes and afterwards endeavor to offer means of abrogating them. The seven basic causes are as follows: ignorance, haste, dependence on others, thoughtlessness, lack of discipline, defects in physical condition and inadequate illumination.

The importance of these various causes of accidents is sufficient to justify detailed discussion.

Ignorance: Men are assigned tasks without being given proper instructions as to the safe performance of their work, or an investigation of their ability to complete the task in accordance with the instructions.

Haste: Electrical workers as a class tend to do everything possible to complete work in the minimum possible time. Perhaps this is due to the fact that electrical maintenance jobs usually mean power interruptions, and interference with industrial production.

Dependence on Others: All industrial workers are prone to assume that fellow workmen will perform their function in the chain of operations which assures complete safety protection. And as a result, many are lax in checking safety precautions, unless they are continually urged to do so by their foreman.

Thoughtlessness: Failure to consider the possible effect of an action either separately or in combination with a series of actions on the part of his fellow workmen.

Lack of Discipline: Orders are usually disobeyed because the worker feels that he can give a quicker and better service by a short-cut method, or because he is not sold on safety and feels the rules and regulations needless. As a result groups of men frequently take hazards which are unnecessary and contrary to the rules. The only way to cure this tendency is to enforce strict disciplinary measures each time that an instance of such is discovered.

Accidents due to the lack of discipline are so prevalent as to make examples superfluous.

Physical Defects: There are three physical defects which cause accidents, namely, poor vision, poor hearing and poor co-ordination. Poor hearing and poor vision are defects which are easily discovered by conscientious medical examination. A man having such defects rarely enters an organization where his employment would be hazardous. However, it frequently happens that after original employment, the men are transferred from one class of work to another without medical examination and as a result are given work, for which they are physically unsuited. Poor co-ordination is a defect which has not been given careful attention by the medical authorities employing electrical workers as its importance justifies. Any defect in the nervous system that handicaps a man in having his hands perform what his brain directs makes him unfitted for electrical work. Unfortunately, the degree of co-ordination is a thing of which we have no direct measure. Until some standard of selection is developed this defect can only be prevented by observation on the part of the foremen.

Inadequate Illumination: The necessity for 24-hr. operation in the steel industry requires the electrical-maintenance department to make repairs regardless of the time that a failure occurs. It, therefore, frequently happens that men are required to make repairs on high-tension equipment in the dark. While it is as simple to disconnect lines during darkness as in daylight, the hazards of climbing and working in the air under poor illuminating conditions are so much greater that provision should be made to properly illuminate such jobs as they occur. So far, little attention has been paid to this side of the industrial safety problems. This hazard can be readily eliminated by equipping switchhouses, substations, etc., with a system of battery-fed lighting and providing portable flood lights for field work.

This paper has endeavored to point out some things which appear necessary to eliminate accidents in the operation of steel-mill transmission systems. Of these, by far, the most important feature is education.

Application of Tapered Roller Bearings on Roll Necks

By FRED WALDORF

District Manager, The Timken Roller Bearing Co., Canton, O., Steel Mill Division.

NO RECENT innovation in the steel mill industry has proved itself such a boon as the advent of anti-friction bearings for roll necks. Experience has demonstrated that where an idle roll running on plain bearings must be started by traction there exists a tendency to score or flatten the surface of the roll, which tendency to a large degree disappears when anti-friction bearings are used on the roll necks. Savings in power as high as 60 per cent have been obtained through the use of such bearings in rolling mills.

About three years ago our company decided to change over one of the mills at the Timken plant and run a series of exhaustive tests to determine the exact requirements of the bearing equipment and installation.

A three-high 22-in. bar mill roughing stand, which is used to roll alloy steel, starting with a bloom about 8 in. x 9 in. and reducing it to about 4 in. x 4 in. in seven passes, was

Average Power Savings with Roller Bearings

Size of billet	3 in. x 3 in.	
Size of final section	2½ in. x 1 in. oval	
Square inches of reduction	7.02	
Material	Nickel-Molybdenum steel	
	Plain	Timken
Total number of billets	46	31
Temp., deg. F	2167	2091
R.p.m.	547	529
Max. kw.	484	282
Total kw.-hr. per ft. of billet	.3108	.1910
No. load kw.-hr. per ft. of billet	.1061	.0570
Net rolling kw.-hr. per ft. of billet	.2047	.1340
Per cent saving affected by Timken bearings:		
Total operating load	38.6	
Friction load	46.3	
Net rolling load	34.6	

selected. Bearings were applied to the middle roll only. To meet the existing space available a bearing with a 13½-in. diameter bore and 22-in. outside diameter was designed. This bearing was mounted on the neck of the middle roll as shown at the left in the diagram, and the mill was placed in service on March 3, 1925.

The mill operates at a speed of 60 r.p.m. and the bearing used is rated at 400,000 lb. radial load at this speed. After rolling about 5,000 gross tons, the bearings were removed for inspection and found to be in good condition. It was then decided to reduce the capacity of the bearings and run further tests. This was accomplished by removing two rows of rollers from each bearing and on May 10, 1925, the middle roll was replaced in the stand with the bearings on the neck mounted as shown at the right in the illustration.

During the time the half bearing shown above at right was in operation after about 20,000 tons of steel had been rolled, a cold test was run on the mill. That is, the temperature of the steel was reduced to a point where something in the system would give way due to the excessive load. In this case the motor crab broke and the mill stopped. To determine the load to which the bearings were subjected, a Brinell test was made during the cold test.

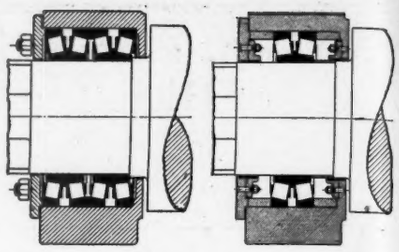
Upon failure of the motor crab, the bearings were found to be in excellent condition and no impression whatever could be discovered on any of the rolls or races.

The splendid showing of these bearings under the severe operating conditions prompted us to run tests with still further reduced bearing capacity. Every third roll in each cage was removed and the bearings were again placed in service on January 4, 1926. After rolling a total of 6,559 gross tons of steel, the bearings failed on February 10, 1926.

It is believed that if, when removing every third roll, a new cage had been made up to permit of evenly spacing the remaining rolls, the bearings would have had a much longer life. The bearings were then replaced with cages having complete sets of rolls and mounted as shown at the right, and rolling was continued until over 40,000 gross tons of steel had been rolled by the mill.

The above test assured us that our bearings would answer all of the load requirements which this type of service would impose upon them. We desired, however, to determine also the power saving which might be obtained from an application. These tests were conducted on a three-high, 16-in. bar mill, from February 15 to May 11, with plain bearings on the necks. Tests were made every day on all sizes of billets rolled and it should be noted that the testing did not cover one continuous period of operation on plain bearings and then one on roller bearings, but testing was done first on plain bearings for a short period, then on roller bearings alternating over short intervals.

The accompanying table shows the most extended test we were fortunate in making as it covered a total of 77 similar billets. Forty-six of these billets were rolled on plain bearings and thirty-one on Timken bearings.



These bearings are mounted on the middle roll neck.

The original 22-in. roller bearing mounting is shown at the left, and the reduced capacity mounting at the right.

Bearings for Use in Rolling Mills

By C. J. Klein

Engineering Dept., United Engineering & Foundry Co., Pittsburgh, Pa.

BEARINGS used in connection with rolling mills and auxiliary equipment have received more thought in the way of proper application and design than any other single item in the construction of this type of equipment, especially so within the last decade. This is mainly due to the fact that approximately 30 per cent to 60 per cent of the power expended by the motor or engine is lost in bearing friction, depending on the application. Another item of considerable cost is the lubricant and additional provisions have been made from time to time for collecting and returning this oil to the supply reservoir.

The use of roller bearings has been steadily increasing until at the present time about 60 per cent of the bearings in rolling mill auxiliary equipment are of the roller type.

Mill roll bearings usually consist of babbitt in a great variety of analyses and combinations, babbitt with bronze strip inserts, brass or bronze of various combinations, and brass or bronze with babbitted inserts. Due to the fact that roll journals are limited in both diameter and length, the diameter must necessarily be large in proportion to the body diameter of the rolls to obtain the maximum bearing area possible and also to secure the maximum amount of strength with least length. A long journal causes greater stresses when it bears on its outer edge, thereby causing considerable roll breakage. Oil lubricated and roller bearings have not yet come into their own for this class of service.

The most typical designs of bearings, that have been used and are still in service, are as follows:

Bearings for mill tables and auxiliary table conveyors probably offer the greatest variety in design and use of materials. Table roller bearings vary approximately from 1½ to 9 in. in diameter, and in lengths up to about 20 in.

Some of the types of lubrication employed are chain or ring oil with or without a circulating system which maintains a fixed level in the reservoir, oil lubricated through wick

feed, force or gravity feed, or cotton waste. Grease lubricated from a central forced-feed system or individual fittings for filling reservoir from a grease gun, or grease pockets, which are filled by a paddle through a large opening in the cap. Splash lubrication proves very satisfactory where the speed of the drive gears is sufficient to throw the oil which is collected in troughs and returned to the bearing reservoir.

Bearing mountings and materials of a large variety are in service, of which the following are worthy of mention: bronze or babbitt, ring or chain-oiled, mounted in pillow blocks or supports cast integral with the girders; roller type of the solid, hollow or tapered roller variety. Ball and socket, as well as straight seat supports, have been used. Die-cast babbitt shells have also been used successfully. Ball bearings are used on light tables and have the advantage of taking very little space.

An Analysis of the Motor Bearing Problem

By FRANK W. CRAMER
Assistant Superintendent, Electrical Department, Bethlehem Steel Co., Johnstown, Pa.

IN A paper delivered before this association in 1921, A. M. McCutcheon, Vice-President and Chief Engineer, Reliance Electric & Engineering Co., called attention to the advantages and disadvantages that could be expected in the adoption of anti-friction bearings in steel mill motors. After a lengthy discussion of anti-friction bearings, he suggested that the steel mill electrical engineers evolve a plan to carry on further experimental work with ball and roller bearings, and report their results to the association.

Late in 1922, L. J. Hess, Chief Electrician, Youngstown Sheet & Tube Co., presented a paper entitled "Roller Bearings Applied to Mill Motors," giving the results obtained in changing sleeve bearings in existing mill motors to anti-friction bearings.

In September of that year, D. M. Petty, Chairman of the Standardization Sub-Committee on Motors, presented a report which included the replies obtained through a questionnaire on the use of anti-friction bearings.

The outstanding feature of this report was the fact that 37 per cent of all a.c. motor failures, and 41 per cent of all d.c. motor failures were attributed to insulation failures due to oil. However, in justice to sleeve bearing designers, it can be pointed out that these totals included all motors then in service whether manufactured in 1890 or in 1922.

This high percentage of failures cannot be attributed entirely to sleeve bearing design. It is a well-known fact that oilers in steel mills give the motors plenty of oil, and much of that found in the windings of the older-type motors, comes directly from the oil can, rather than from the bearings. Although oil does tend to soften some kinds of insulating varnish, and may cause insulation failure, it is not so serious as some people believe. It is common practice to immerse transformer coils, compensator windings and so on in oil, which does not attack the insulating varnishes.

Unfortunately, the misinterpretation of these tabulations from the questionnaire aroused an undeserved prejudice against modern sleeve bearings.

One of the advantages of sleeve bearings is that a mill mechanic can manufacture a new one or, in the general run of work, a worn bearing can be rebabbited and made ready for service again. The ease and low cost with which this can be done, however, cause many mechanics to overlook the importance of proper methods and materials. There are thousands of poorly-made bearings in operation today whose performance is being compared with high-class anti-friction bearings.

Then it may be that this home-made bearing is not given a fair chance after it is installed. There are thousands of motor installations in this country where flexible couplings and proper mountings would accomplish wonderful reductions in bearing costs. Vibration that is transmitted to the armature shaft, pounding the bearings 24 hr. a day, will shorten bearing life.

Anti-friction bearings will stand more vibrations and hammer blows than a babbitt bearing because steel will not flow under the same pressures that will rapidly destroy a babbitt bearing.

These remarks are written to show that sleeve bearings collectively, both in mill manufacture and maintenance, do not make a fair comparison with the factory-made anti-fraction bearing. But from an operating standpoint, their simple construction and ease of fabrication by the average mechanic, are a form of insurance against long delays when one fails and a spare is not at hand.

The real advantage of the ball or roller types over the sleeve bearings is in the starting friction which, in case of the former, is practically the same as the running friction. In sleeve bearings, the starting friction is comparatively high, but drops off rapidly as the shaft begins to rotate, and the oil film is established. This unfavorable comparison of starting frictions should not be assumed to apply to running conditions.

Another of the often discussed points is the life of the bearings. Examples of sleeve bearings can be found that have given thirty or more years of service; perhaps the same can be said of anti-friction bearings, so that under ideal conditions either type should outlast the machine.

Another comparison often made is on maintenance costs, particularly oiling. It is claimed that anti-friction bearings need be oiled or greased only once a year. It is also claimed and proven that modern sleeve bearings will operate a similar period without additional lubrication. When a fair comparison is made on oiling costs, it appears that neither type of bearings has any great advantage so far as oil or grease leakage is concerned.

An item of interest is spare equipment, which determines the inventory account. Sleeve bearings can be fitted on an armature and little care need be taken with its storage until needed. It is doubtful whether the anti-friction type would operate if neglected in some millwright's shanty with no particular attention paid to keeping them dry or filled with grease.

As stated before, almost any in-

spector or mechanic can scrape a sleeve bearing and get a fit. In case of breakdown with no spare anti-friction bearings on the new armature shaft, could they fit the old bearings on the new armature in the field, or would it be a shop job?

Another item worth consideration is the actual increase in the inventory account if anti-friction bearings have to be purchased for the spare armatures, over the cost of sleeve bearings for the same purpose.

An analysis such as this, digesting claims and counter-claims for both the sleeve and anti-friction bearings, makes it logical to conclude that there are on the market first-class bearings of both types that motor manufacturers are willing to install on any general-purpose motor.

At the present time about 20 per cent of steel mill bearing users are ardent advocates of anti-friction bearings for almost every installation. There are another 20 per cent who insist on sleeve bearings for all installations. That leaves about 60 per cent, who represent the majority; they insist on the type of bearing that gives the least trouble and lowest maintenance cost.

As a result, all the large motor manufacturers are forced to carry tools, patterns, castings, etc., to equip their motors with either type of bearing. An example of this can be found in the new G. E. motor that is built to the A.I. & S.E.E. standards, where the over-all length of the motor could be shortened and wasted space in housings eliminated, if it were certain that all customers would ask for anti-friction bearings.

Maintenance costs and continuity of service of the types of bearings used will be the deciding factor. It will not be a question of one bearing operating thirty years, but how many of each type in thousands of installations fail the first year, the second year, and so on, from all causes collectively.

If we can assemble sufficient data on life, cost, and service on anti-friction bearings, and compare them with similar data secured from modern, precision-manufactured sleeve bearings, we may be able to make definite recommendations for each type on different classes of motors.

Anti-Friction Bearings on Roll Necks of Rolling Mills

By E. C. GAINSBORG

Engineer, SKF Industries, Inc., New York, N. Y.

IN NUMBER of units, next to electric motors, rolling mills predominate in the steel industry. It seems desirable to concentrate greater efforts at this time, on the study of applying anti-friction bearings on roll necks.

The design of plain-bearing mills has been largely on the basis of "broadening out" from precedent to precedent. The proportioning of rolls, that is, the diameter and length of the barrels and roll necks, are the result of established experience. Space limitations in rolling mills, particularly for change-over jobs, make the problem a very difficult one for anti-friction bearings. Because the outside diameter of an anti-friction bearing is limited by the diameter of the barrel roll, and the bore, controlled by the roll neck diameter, is made large to withstand heavy stresses, there is no choice as to the bore or outside dimensions of a bearing which may be used. This condition makes it very necessary that we have accurate data on rolling pressure, in order to determine the possibility of applying bearings of standard size, or the necessity of applying bearings of special dimensions to fit within the space limitations.

Cold Rolling—In the rolling of cold strip there exists a critical pressure below which no reductions can take place. This critical pressure varies with the hardness of the material, dimensions of the roll and width of the stock. It seems reasonable to assume that the load value corresponds to the yield point of the stock rolled.

Journal pressures vary directly with the width of stock rolled; so it follows that the wider the stock, the greater the journal pressure. This condition limits the possibility of applying anti-friction bearings of standard dimensions, when considered for changeover of plain-bearing mills for the rolling of stock of considerable width. On the other hand, there should be no difficulty in equipping change-over mills used for rolling stock of narrow width.

Hot Rolling—The potential value of anti-friction bearings if applied to two-high, hot merchant mills, is reflected in a marked reduction in manufacturing cost, because of substantial power saving.

Tests conducted on a mill operating at about 500 r.p.m. and used for rolling stock with a section of 1½ in. x ⅜ in., showed that 30 to 40 per cent of the power input was consumed in overcoming the friction of plain bearings.

This exceedingly high and ineffective power consumption, is traceable to the high speed of operation, heavy journal pressures and the duplication of journals at each end of the mill; in other words, the separating force that occurs when stock is passed between the rolls, results in journal pressure at the roll necks of the upper and lower rolls that is the equivalent of duplicating the load.

Use of anti-friction bearings would make it unnecessary to have water-cooled housings. If the housings are properly designed it should be necessary to introduce or change the lubricant only at the end of 100 to 150 hours of service.

There are certain outstanding advantages that the use of anti-friction bearings offer, which are not had with plain bearings. These are, control of gage thickness, brought about because of the close limits to which ball and roller bearings are manufactured, and speed of operation can be increased without undue heating. This is reflected in increased production; maintenance, in so far as lubrication is concerned, can be handled more effectively and at a lower cost.

Although there are installations which have been operating satisfactorily for limited periods of time, there are still many variables in the problem which make it impossible to apply the anti-friction bearing universally. Each individual application is a separate engineering problem and must be solved as such; consequently to be safe, the development must not be forced.

Application of Synchronous Motors in Steel Mills

By HARRY A. WINNE

Industrial Engineering Dept.,
General Electric Co., Schenectady, N. Y.

THE synchronous motor is not at the present time applied in steel mill service to nearly as great an extent as in some other industries. This statement and, in fact, the whole of this paper, refers to motors furnishing power for machine, roll and other drives. Nevertheless, there is a field for it, and it will perhaps be profitable to spend a little time studying its operating characteristics and trying to determine when it should be employed.

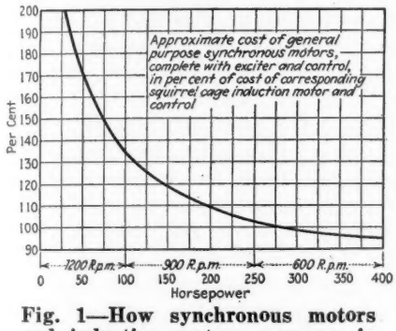

Approximate cost of general purpose synchronous motors, complete with exciter and control, in per cent of cost of corresponding squirrel cage induction motor and control
Per Cent
1200 R.p.m.
900 R.p.m.
600 R.p.m.
Horsepower

Fig. 1—How synchronous motors and induction motors compare in cost.

The cost figures include complete hand-control apparatus for both types of motors, as well as direct-connected exciters for the synchronous motors.

In this field the synchronous motor is, of course, the competitor of the squirrel-cage induction motor, and it is, therefore, of interest to compare these two types.

The mechanical construction of the synchronous motor can be made fully as rugged as that of the induction motor. In fact, standard induction motor frames, end shields as well as bearings are often used in the process of fabrication. The synchronous motor has the advantage of a much larger air gap than can be incorporated in an induction machine which helps to decrease maintenance.

On the basis of efficiency, the unity-power-factor synchronous motors are superior to induction motors, except at part loads on the smaller sizes. In larger machines the difference is even more marked, reaching 2.5 or even 3 per cent in some cases. Motors operating at 80 per cent power factor have efficiencies considerably below those of the unity-power-factor machines, especially in capacities below 200 hp. In the smaller sizes the efficiency of an 80 per cent power factor synchronous motor is less than that of an induction motor.

The starting torque of the synchronous motor is usually better than that of the corresponding squirrel-cage induction motor, and at least 100 per cent pull-in torque can be obtained, so that with one of the standard general-purpose synchronous motors it is easily possible to start and synchronize while delivering full rated torque. The synchronous machine has better starting characteristics than the induction motor, because while both utilize a squirrel-cage winding for starting, that on the synchronous motor is designed purely for starting purposes, while that on the induction machine must be designed primarily to give good operating characteristics after the motor is up to speed.

The first cost of small-sized synchronous motors is considerably higher than that of induction motors, but as the capacity increases, the disparity in cost decreases and in large sizes, say 300 hp., 600 r.p.m., and above, the synchronous machine usually has the lower cost. The approximate ratio of the cost of synchronous motors to that of corresponding induction motors is shown graphically in Fig. 1. In making this comparison, the cost of complete hand-control apparatus is included for both types, as well as that of direct-connected exciters for the synchronous motors. If direct current is available, as it always is in a steel mill, the exciter can be omitted and the cost ratio is then much more favorable to the synchronous motor than the curve shows.

Perhaps the most desirable feature of the synchronous motor is its ability to furnish leading reactive kva. for power-factor correction. Synchronous motors for main roll service are usually designed for 80 per cent leading power factor at full load. The curves in Fig. 2 show for both unity-and 80 per cent power factor motors the approximate amount of leading reactive kva. available at loads other than normal, with the field excited at the full-load value. The curves given are only approximate, and values will vary considerably for different motors. It is evident that even at 150 per cent load, an 80 per cent power factor machine still furnishes a considerable amount of correction.

The fact that slow-speed, 60-cycle induction motors operate at undesirably low power factors has necessitated the use of reduction gears in many cases where for other reasons a direct drive would have been preferable. A synchronous motor, however, has a good power factor regardless of its speed, and hence may make possible direct drive where an induction motor would require gearing.

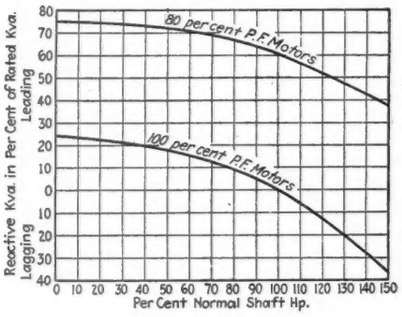


Fig. 2 — These curves shows the amount of leading reactive kva. available at loads other than normal for both unity- and 80-per cent power-factor motors.

Turning to consideration of the field of application, it is evident that if good power factor and high efficiency were of no value, we would never think of using the synchronous motor. However, we know that power to supply losses does cost money, as do generator capacity to supply wattless kva. and cables and switches to carry it. It is by comparing the cost of these factors with the difference between the cost of a synchronous and an induction motor that we can determine whether the use of the synchronous machine is justifiable.

In most steel mills power costs are comparatively low and it is difficult to justify the increased cost of the small synchronous motor on the score of efficiency. However, if the drive is of such a nature that the motor will run fully loaded a good portion of the time, this point should be very carefully investigated. Similarly, as

regards power factor correction, most mills have such a large power load that the corrective effect of a small synchronous motor is not worth a great deal; but in a manufacturing plant where a few such motors may constitute the major portion of the load, and where the power cost may be appreciably affected by power factor as well, it is obvious that the better efficiency and power factor of the synchronous motor will often more than counterbalance any difference in first cost.

For slow-speed small-capacity drives, such as on direct-connected air compressors and the like, the synchronous motor is usually employed because of the very poor power factor and high cost of small, slow-speed induction motors. There is an interesting feature in connection with the application of synchronous motors to reciprocating compressors. Due to the pulsating torque required by the load, the drive must have a suitable flywheel; otherwise the motor may pulsate or hunt sufficiently to fall out of step. The size of the flywheel must be carefully determined in order to limit the pulsations to a safe value. At first thought it appears ridiculous to use a flywheel on a synchronous motor, but here is one application where it is absolutely necessary.

The synchronous motor should always be given very careful consideration for all constant-speed drives above, say, 200 hp. In these capacities the synchronous motor will cost little more and may cost less than the induction machine, and it will certainly have better efficiency and power factor. The high efficiency is a particularly important factor when the motor will run continuously, or nearly so, at full load, as is the case on many pump and compressor installations. That this fact is well appreciated is evidenced by the number of synchronous machines which are now in service driving water pumps, compressors, and the like.

The high efficiency and power factor of the synchronous motor warrant its careful consideration for constant-speed general-purpose drives of possibly 50 hp. and greater capacity. The minimum capacity of drive at which the synchronous motor should begin to be considered will, of course, vary in different installations, depending on size of the power system, existing system power factor, and cost of power.

Experience has already demonstrated the entire practicability and desirability of using synchronous motors for driving some types of metal rolling mills. The usual large capacity of such units makes high efficiency and power factor of extreme importance. It is certain that synchronous motors will be widely employed in this service in the future, and it is the problem of the engineers who are responsible for the purchase, application, and design of these machines to see that they are used not only widely, but wisely.

Electrical Installations in New Structural Mills, Homestead Steel Works

By C. A. MENK

Electrical Superintendent, Homestead Steel Works, Carnegie Steel Co., Munhall, Pa.

THE Homestead Steel Works is located in the Monongahela River Valley about 10 miles from Pittsburgh. It is made up of a blast furnace plant with seven blast furnaces located on the north side of the river. Across the river are 65 open hearth furnaces, two universal slabbing mills, two blooming mills, five sheared plate mills, two universal plate mills, two structural finishing mills, one axle making plant, and an armor plate department.

The mills to be described, known as the new structural mills, consist of two groups of mills, in which electric drives were installed because of their inherent economy and the saving in operating labor.

It was necessary to install an additional 15,000-kw. turbo-generator in the power house at Carrie furnaces to supply the increased demand for power for these two new groups of mills. This brings the generating capacity at the Carrie furnaces up to 42,800 kw., made up of the following units:

2—15,000-kw. turbo-generators	30,000 kw.
3—1,600-kw. gas-engine-driven generators	4,800 kw.
2—2,500-kw. gas-engine-driven generators	5,000 kw.
1—3,000-kw. gas-engine-driven generators	3,000 kw.
Total	42,800 kw.

A 3,000-kw., low-pressure turbo-generator located in the Homestead Steel Works makes the total generating capacity of the system 45,800 kw.

Power is transmitted from the Carrie furnaces power house to the new structural mills over four-three-phase, 6,600-volt, 25-cycle circuits. The cable is 500,000-cir.mil., hard-drawn, stranded copper except for the 1,200-ft. span over the Monongahela River and two long spans over the mill buildings at the Homestead works where steel-reinforced aluminum cable, equivalent to 500,000-circ.mil. copper, is used. The transmission line is supported on steel towers throughout.

These circuits are fed into a bus through four truck-type oil circuit breakers having a rupturing capacity at 6,600 volts of 36,000 amp. two o.c.o. duty cycle. This bus extends for a distance of 850 ft.

The No. 1 group of mills is served by 28 soaking pits; the covers of these pits are motor-driven. The blooming mill serving the No. 1 group has 44-in. diameter pinions and the screwdown is equipped with two series-wound, mill-type motors with magnetic brakes. All mill auxiliary motors are supplied with washed air under pressure through a system of piping connected to a ventilating fan. The auxiliary control for these motors is located in a room adjacent to the motor house.

The main rolls are driven by a single-unit, reversing motor having a continuous rating of 7,000 hp. at 50 r.p.m., and a maximum torque of 2,000,000 lb.ft. This motor is supplied with variable voltage direct current through a flywheel motor-generator set consisting of a 5,000-hp., 6,600-volt, three-phase, 25-cycle induction motor, a 100,000-lb. flywheel and two 3,000-kw., 700-volt, 368-r.p.m. generators operating in parallel. The ventilating equipment for the reversing motor consists of a 60,000-c.f.m. fan with air washer. All station auxiliaries are driven by 220-volt induction motors. The mill is completely electrified and is operated by two men in the mill pulpit.

The blooms are cut by an electrically-driven shear equipped with one 250-hp., 220-volt wound-rotor induction motor for the main drive and a small motor for operating the clutch.

The mill of the two-high reversing type is driven by a 5,000-hp. direct-current reversing motor. The flywheel motor-generator set for this motor consists of a 5,000-hp. induction motor, a 100,000-lb. flywheel and two 2,100-kw., 700 volt, 368-r.p.m. generators operating in parallel.

The structural mill is driven by a 6,000-hp., 30-pole, 98-r.p.m., 6,600-volt, three-phase, 25 cycle wound-rotor induction motor. The 28/32-in. mill is run by four operators located on two stationary pulpits spanning the four traveling tables, two on each side of the mill. Push buttons located in the mill pulpit provide for emergency stopping and starting of the 6,000-hp. motor.

Material which cannot be sheared is cut into desired lengths by a motor-driven cold saw which is equipped with a 250-hp., 220-volt wound-rotor induction motor.

Paralleling the No. 1 group of mills is the No. 2 group. Hot ingots ranging in weight from 12,000 lb. to 30,000 lb. are delivered to a 54-in. mill. This mill is the largest blooming mill ever built. It is driven by the largest reversing motor in the world, which has a continuous rating of 8,000 hp. at 40 r.p.m. and a maximum torque of 3,500,000 lb.ft. The flywheel set consists of a 5,000-hp. driving motor, a 150,000-lb. flywheel, and two 3,500-kw., 700-volt, 368-r.p.m. generators operating in parallel. The motor is supplied with 60,000 cu.ft. of washed air per minute through a ventilating system similar to that which supplies the 44-in. mill. Two operators control the main and auxiliary drives in this mill.

The shear for cutting the circular bloom into desired lengths for wheel blanks is driven by two 275-hp., 1-hr. rating, mill-type motors.

In the roughing and intermediate mills the edging stand is driven by a 2,000-hp., 57/163-r.p.m. reversing motor and the main stand is driven by a 7,000-hp., 50/80-r.p.m. reversing motor. Both motors receive d.c. power from a 6,000-kw., 700-volt flywheel motor-generator set. The finishing stand is driven by a 4,000-hp., 6,600-volt, three-phase, 25-cycle, 83-r.p.m., wound-rotor induction motor.

The roughing and intermediate mills are each equipped with an automatic screwdown device which enables one man using a single master switch to set the three screwdowns, which automatically stop at predetermined settings by means of a specially-designed limit switch, and secure the proper speed relations between the motors driving the main and edging stands for any condition of drafting.

Two 1,500-kw. synchronous motor-generator sets supply the necessary 230-volt direct current for the finishing mill auxiliaries. An automatic switchboard forms part of this equipment and provides complete protection without any attendants. The sets are brought up to speed, synchronized and connected to the d.c. bus automatically. The load of the two machines is also balanced automatically. There are also three flywheel motor-generator sets which supply the d.c. power to the main drive reversing mill motors. The total generating capacity is 16,200 kw.; the motors total 15,000 hp.

A variable-speed motor drives a lineshaft to which is belted all of the recording instruments. All charts, therefore, have the same time base. The same instruments are used for five reversing motors. The Clark pendulum marks all charts simultaneously.

Sixty-one cranes serve both groups of mills and yards. The hydraulic pressure pumps are driven by 400-hp., 220-volt, three-phase, 25-cycle synchronous motors equipped with magnetic control for automatic starting. Two air compressors are driven by 250-hp., 220-volt, three-phase, 25-cycle synchronous motors.

Three 1,500-kw., single-phase, 25-cycle, 6,600/220-transformers supply all the power used by the low-voltage a.c. motors. Another transformer, located in the same room, supplies the power for lighting.

Fifteen Years of Steel Mill Illumination

By WARD HARRISON

Director of Illumination, National Lamp Works of General Electric Co., Cleveland, Ohio

IN THE years 1911, 1912 and 1913 the writer was privileged to present before the Association of Iron and Steel Electrical Engineers, a series of papers dealing with lighting practice in the steel industry. Since then but one paper on the subject has appeared on an annual convention program.

Statistics compiled by the U. S. Department of Labor show that the average cost of all commodities which go to make up the total expenses of an individual or corporation are now 68 per cent in excess of what they were in 1914.

If we assume this increase as a basic figure, we might say that those industries in which the price increase of the products manufactured has been less than 57 per cent have improved their efficiency

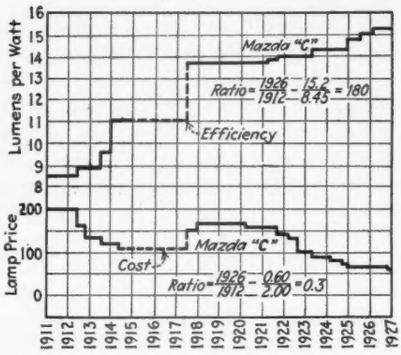
by an amount more than the average for the country as a whole. Men of the steel industry are to be complimented on the fact that the composite price of finished steel products has increased but 59 per cent since 1914, this price being based on the *Iron Age* review of market quotations.

Let us consider what has happened in the artificial lighting field in the same period. Fifteen years ago we were just at the close of an era during which the standard illuminant for steel mills was the 250-volt, 3-amp. direct-current enclosed carbon arc lamp, and at the beginning of the year in which the Mazda lamp became the almost universal illuminant.

At that time Mazda lamp manufacture was limited to the B or vacuum type of lamp, in the larger sizes of which an efficiency of 8 to 9 lumens of light per watt were obtained. It was during this time that Dr. Langmuir in the General Electric research laboratories performed his first experiments on gas-filled lamps. Without going into too much detail, it may suffice to say that in the 15 years since those first experiments were conducted, the efficiency of light production in the same sizes of lamps has been approximately doubled.

An idea of the progress made may be gained by referring to the accompanying chart which gives graphically the efficiency and the lowering in price of the 150-watt size of lamp, which is very closely typical of the line as a whole. During the 15-year interval between 1912 and 1927, it will be noted that the light output of this lamp has substantially doubled, and its list price has decreased from $2 to 60 cents. So far as the lamp itself is concerned, its cost per unit of light delivered has gone down in the ratio of nearly 6 to 1 during the time when other commodities have increased by 68 per cent.

In the total cost of light, the cost of electrical energy is, of course, a far larger item than the cost of the lamps themselves. In order to obtain for this paper a reliable basis on which to compare the cost of light and power energy in 1912 with the cost in 1927, figures have been obtained from nine plants located in five different cities representing the principal manufacturing districts of the iron and steel industry. The data obtained by this survey revealed that there



Efficiency-cost curves of the 150-watt Mazda lamp.

was on an average, combining those mills generating their own power and those purchasing their power, an increase of 28 per cent in the cost of wholesale power.

Twenty-eight per cent is far below 68 per cent, the general average increase in the cost of commodities, and it is evident that in the manufacture of power as well as of lamps, the electrical industry has set a remarkable standard of efficiency and economy.

Nevertheless, many of our mills in the iron and steel industry are very badly lighted, and almost without exception they are on a decidedly lower basis than other progressive industries.

In the motor car industry the purchaser can actually buy for 86 cents as much as he could for $1.00 in 1912. Records of the largest manufacturers of electrical apparatus and machinery show that the net selling price of all its products is but 15 per cent more than in 1912. It is evident from these figures that the efficiency of these two industries is at least 50 per cent higher than for the average of the country as a whole and 40 per cent higher than for the steel industry. Is it not significant that these two are also the best lighted industries in America?

In the General Electric Co. plants the standard for installation is a wiring layout which will supply 3 watts per square foot with a line drop from the panel board not exceeding 1½ volts (branch circuits will carry 5 watts per square foot at not greater than a 2½-volt drop.) Lighting fixtures have also been standardized upon which will satisfactorily provide correspondingly high levels of illumination as mentioned above. Since 1921 substantially 75 per cent of the total area of the G. E. plant has been lighted in accordance with these standards.

One of the greatest contributions that has been made in the study of light and its bearing on accidents is that of R. E. Simpson of the Travelers' Insurance Co. In his first survey ten years ago in which 90,000 accidents were investigated, 25 per cent were traceable in whole or in part to improper or inadequate lighting. Even with the very commendable Safety First movements in protecting dangerous and dark places and the improved illumination placed in effect since that time, Mr. Simpson's statistics indicate that there are still 15 per cent of our industrial accidents which may be attributed to inadequate illumination.

Main Points in the Discussion at Pittsburgh Convention

COMMENTING on the papers presented at the session of the Safety Engineering Division, Walter Greenwood, Carnegie Steel Co., stressed the importance of safe construction and installation of electrical equipment, and pointed out the need for complete directions covering the operation of equipment. Many accidents are the result of ignorance more than anything else. Accidents arising from this and other causes can be reduced by educating workmen and operators in the proper handling of equipment and the precautions necessary. It costs more to provide equipment that is absolutely safe to operate, but in view of the losses caused by accidents, the extra expenditure is justified. He also called attention to the fact that education involves much more than merely calling attention to acts that are the result of ignorance or thoughtlessness.

A. J. Standing, Electrical Supt., Saucon Plant, Bethlehem Steel Co., commented on the fact that oftentimes electrical construction work must of necessity be done hurriedly, and that other than electrical workers are employed in close proximity

to high-tension equipment. Care and time are required to acquaint such men with the hazards involved. It was his feeling that it is perfectly justifiable to delay the completion of construction work, if necessary, in order to decrease accident hazards.

F. W. Cramer, Ass't. Electrical Supt., Bethlehem Steel Co., Johnstown, Pa., spoke of the importance of providing adequate protection for equipment under all conditions and mentioned the fact that motors may be provided with switches that are suitable for the normal starting and running currents involved, but which are inadequate in case of a short circuit. In one instance, a workman was killed because a circuit breaker did not open immediately, due to a time delay feature for taking care of the heavy current drawn during the starting period.

The papers presented in the symposium on the use of anti-friction bearings evoked an unusual amount of interest. In commenting on F. W. Cramer's paper, D. M. Petty, Electrical Supt., Bethlehem Steel Co., Bethlehem, Pa., stated his feeling that Mr. Cramer's remarks were well taken. He felt that figures compiled from questionnaires on motor failures due to oil leaking from sleeve bearings did not do full justice to modern sleeve bearings, inasmuch as many of the motors represented were designed and built many years ago and hence do not have some of the recent improvements in design.

Prior to the advent of interpoles, pedestal-type bearings were used in large, general-purpose motors, so that the bearings were relatively some distance away from the armature and no trouble was experienced with oil getting on the windings. With the use of interpoles and an increase in the size of motors, the bearings were brought closer to the armature and with the design of sleeve bearings then in use trouble was often encountered. However, the design of sleeve bearings has been considerably improved during the past few years. Mr. Petty also felt that sleeve bearings possess decided advantages in the ease with which they can be fitted, when replacement or overhauling is necessary. In his plant there are a good many motors upwards of 40 years old which are still running with the original sleeve bearings.

With regard to the application of anti-friction bearings to roll necks, Mr. Petty advocated that a careful study be made with the view of standardizing on the inside and outside diameters of bearings intended for the same duty before it is too late for such action.

B. R. Shover, Chairman of the session, promised to bring this matter to the attention of the Bearings Committee of the Association.

In reply to a question by Prof. Trinks, as to how water and scale can be kept out of roll neck bearings, Fred Waldorf, District Manager, Steel Mill Division, Timken Roller Bearing Co., stated that it is the practice of his company to mill five grooves in the bearing collars and fill these with grease. When oil lubrication is used, 12 grooves are employed.

E. C. Gainsborg, Engineer, SKF Industries, Inc., stated that water and dirt could be kept out of bearings by the use of a flinger, set in the bearing.

C. J. Klein, Engineer, United Engineering and Foundry Co., said that a piston ring seal may be used with oil-lubricated anti-friction bearings. With grease lubrication, grooves filled with grease afford a satisfactory means of keeping foreign matter out of bearings.

A. J. Standing, commenting on Mr. Waldorf's paper, expressed the opinion that the savings in power secured by the use of anti-friction bearings seemed to be high in proportion to the power required to roll steel. If such savings can be regularly obtained, the rolling range of a mill would be increased, with the result that it would be possible to eliminate costly transferring of material from one mill to another.

Referring to F. W. Cramer's paper, he expressed the belief that there are many applications to which sleeve bearings are well suited, but advocated a change to anti-friction bearings where necessary.

A. M. McCutcheon, Vice-President and Chief Engineer, Reliance Electric & Engineering Co., in referring to F. W. Cramer's paper, said that noteworthy advances have been made in the design of sleeve bearings, due to the stimulus produced by the increasing use of anti-friction bearings. On various applications both types of bearings have given extremely satisfactory results. He did not want to champion either type for universal use, for each type is better fitted than the other for certain applications. He suggested that operating men study their applications carefully, putting down the advantages and disadvantages for both sleeve and anti-friction bearings. This procedure would give a sound basis for comparing the merits of the two types. He recommended that the use of sleeve and anti-friction bearings be standardized according to types of motors, rather than application.

Mr. McCutcheon also spoke of the difficulty that had been encountered in retaining grease in anti-friction bearings in hot locations. He found that it would leak past a machined fit, but the use of paper gaskets on bearing caps effectively stopped this leakage.

J. L. Brown, Westinghouse Electric & Manufacturing Co., expressed the opinion that Mr. McCutcheon's attitude was fair and that users should analyze their requirements in the light of the advantages and disadvantages of the two types of bearings. He mentioned the fact that one of the advantages of anti-friction bearings, as compared with the sleeve type, is the low starting friction. However, as soon as the oil film has been established in sleeve bearings, the friction drops very markedly. Anti-friction bearings require more care in handling and storing and must be kept clean or serious wear will take place.

In a thorough discussion of H. A. Winne's paper, H. V. Putman, Westinghouse Electric & Manufacturing Co., pointed out the interdependence of the characteristics of modern synchronous motors. He emphasized the fact that any characteristics can be improved or obtained in unusual degree, but this is usually accomplished at the expense of other features. It is important, therefore, that operators clearly define the relative importance of the characteristics desired. He stated that 1,800-r.p.m. synchronous motors of 200 to 300-hp. rating can be started on full voltage with 3½ to 4 times normal full-load current. The limits of full voltage starting are rapidly disappearing for it is easy to secure enough reactance to keep the starting current drawn from the line down to a reasonable value.

In reply to a question, H. A. Winne stated that the control for a synchronous motor is not more complicated than for a wound-rotor motor and that the starting characteristics of synchronous motors are better than those of an induction motor. Furthermore, induction motors are not ideal for all steel mill applications.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Published by McGraw-Hill Publishing Company, Inc.

G. A. VAN BRUNT, *Editor*

New York, July, 1927

Now is a Good Time to Overhaul Equipment

IN MANY industrial plants there is a pronounced slackening of production during the summer months. This respite from the usual rush should be welcomed by every maintenance executive as an opportunity of giving all equipment a thorough overhauling.

There is much to commend the practice, which is followed in many plants, of taking all motors on important drives into the shop at least once a year, for the purpose of testing and painting the windings, checking the condition of the bearings and in general making sure that everything is in first-class condition. Under the circumstances this work can be done carefully and weak spots that might ordinarily go unnoticed can easily be detected and cared for.

At the same time all distribution, control and protective equipment, the lighting, fire alarm and signal systems, and the mechanical elements of the power drives, such as belts, gears, chains and so on, can with profit be very carefully inspected and put into first-class condition.

The management of any plant that can resume capacity production in the fall with equipment that is known to be in perfect operating condition may consider that it has the protection of a very effective form of insurance against high maintenance costs and expensive production delays.

The Electrical Industry Has Lost a Great Leader

IN THE death of General Guy E. Tripp the electrical industry has suffered a loss that has occasioned universal sorrow. His eminence as the chief executive of the great Westinghouse interests for the past fifteen years and his wide and active participation in electrical affairs had brought him in contact with countless numbers of electrical men.

His genial personality, his lovable character, and the deep human understanding that so marked the man had built up for him a wealth of friendships such as few attain. To this host of warm admirers the passing of "the General" has been akin to a personal bereavement.

General Tripp was another of those picturesque personalities that sprang from that great fountain of American enterprise—the country store. From there to railroading and thence into the budding electrical industry, he encompassed in his experience the early organization of electrical manufacturing, the development and management of public utilities, and finally the difficult processes of reorganizing and administering a great metropolitan street railway property, then in the throes of ill-fortune.

The reward for this accumulating record of distinguished service was the high post which he then occupied until the end, interrupted only by the period of his notable contribution during the World War. He had made himself an outstanding leader in the industrial world because he was not only a strong, able and courageous executive, but a wise counsellor, an outspoken defender, and a steadfast friend: a sound and practical idealist, and a champion of progress.

General Tripp was a charming conversationalist and a polished speaker of unusual brilliance. All these appealing qualities had endeared him to the entire electrical fraternity, who followed him through his long and distressing illness with deep sympathy and the sincere hope that he would still have many active years ahead of him. Although his passing was untimely, few men are granted the privilege of a life richer in achievement and in affection.

Where Should the Technically-Trained Man Start In?

THE old question of how a man with good technical training can obtain the necessary practical experience in the way that will be of the most benefit to him and to his employer is always interesting, although the correct answer to it may be a matter of opinion. Nevertheless, the viewpoint of the electrical engineer of a large manufacturing concern on this question may be helpful.

"I think" he said, "that the best place for a technical man to start is in the construction department, and I have planned to have my son do this. Here he will have an opportunity to round out his training with practical work. Most trained men want to start in the office or drafting room, but I have found that when they do this they are seldom able to go very far beyond their first job, because they lack the practical viewpoint and experience.

"The man who starts in construction work and later is put on an erecting or maintenance crew learns why work has to be done in certain ways, with a multitude of things he never thought of before. Also, he learns how to get along with men, which is a most important factor in his future advancement. Men with such training are too valuable to be kept on routine duties."

One of the first things that a technically-trained man must learn is that there is a practical side to the work that has never been put in the textbooks, and probably never will be. He usually learns in a short time that many of these practical kinks are of the utmost importance.

Operating men who are directing the work of young technical graduates can well afford to look ahead and plan a program of shifting them around so that they will have the opportunity of coming into contact with a wide variety of activities. A well-trained assistant can take a big load of responsibility from his superior.

Education Must Supplement Safeguards

THOSE who presented papers, as well as those who took part in the discussion, at the session of the Safety Engineering Division of the Association of Iron and Steel Electrical Engineers in Pittsburgh were in agreement that there is abundant justification for taking all possible precautions to prevent injury to everyone who has to install or operate electrical equipment.

Prevention of injuries from electrical shock involves a good many considerations. For one thing, it means the safe installation of equipment that has been well designed and carefully built from the viewpoint of safety to the operator as well as the possession of desirable operating characteristics. It means the use of automatic control wherever possible, and the thorough safeguarding of all dangerous points. There must also be a willingness to make whatever expenditure is necessary to render an installation as safe and foolproof under every operating condition as it is humanly possible to make it.

A large proportion of accidents are the result of ignorance or thoughtlessness. For the first of these, there is no remedy save an unremitting campaign of education. Posters and signs have an important place in such campaigns, but they should be supplemented by a personal explanation of the hazards involved in operating or working around every installation, and the precautions necessary.

Thoughtlessness and its twin brother, carelessness, require prompt warnings, and may merit dismissal or transfer to some other department if there is frequent repetition of the offense. The man who does not care enough about his own safety or that of others to take every precaution to avoid accidents is a dangerous liability.

From the humanitarian standpoint accident prevention measures need no apology or defense. If justification is needed from an economic standpoint, it can be found in the fact that workmen's compensation or a damage suit for one serious accident would go far towards paying for the safe installation and careful instruction in the proper handling of equipment.

Do Not Lay Out Belt Drives by Guess

ALTHOUGH belt drives have at times been attacked from every possible angle by those favoring other mechanical transmission methods and devices, we still find performance records of belts under favorable conditions that defy the best of arguments against them. From all these discussions about substitute drives some good has resulted. They have pointed out the errors responsible for poor belt operation and demonstrated that rule-of-thumb methods in laying out drives are never safe with any form of mechanical power transmission.

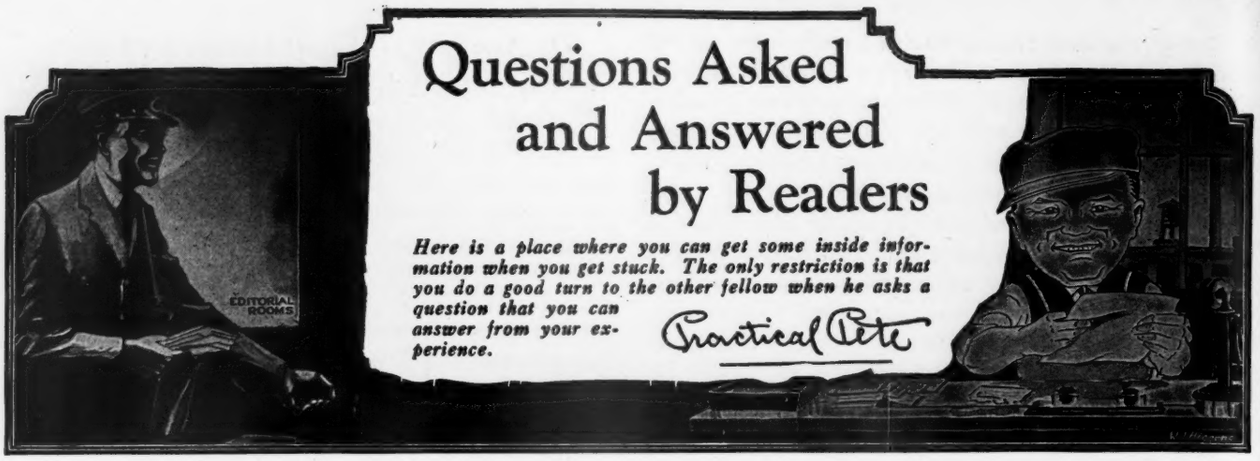
One cause of trouble arises when pulleys with a certain width of face are furnished on machines, without recommendations as to the pulley centers most suitable for the machine, or the width and thickness of belt to use. In such cases the performance of the belt drive used depends upon how much knowledge the man who does the installation work has of the operating characteristics of the machine he is installing, and upon his experience with belts.

Under the best of operating conditions there is no certainty that two machines installed in different plants will be provided with exactly the same belt drive. When a machine is direct-driven the motor is usually mounted on the machine, or instructions are given as to the speed of the motor required. In such a case the machine will perform satisfactorily so far the drive is concerned, because nothing is left to the judgment of the man who happens to install it.

If a belt-driven machine gives poorer service than one driven by a direct-connected motor there is usually some good cause that proper belt experience could easily correct.

We hold no brief for the belt drive under all conditions. It has its disadvantages and its advantages, particularly when starting high-torque machines without sudden jerks, and making it possible to use a higher-speed standard motor at lower cost than in certain direct-connected motor drives. Again, the direct-connected motor has advantages which in many cases are equally as important. What we do maintain is that good performance can be secured from belt drives that are already installed when good belt drive practice is followed.

Anyone who is now operating belts must realize that in order to eliminate belt troubles he should obtain all of the data possible regarding the performance of the machines driven by belts when replacements or changes are required, rather than take a chance on guessing at a remedy for something that has gone wrong before. Guesswork at this time or any other is expensive and is likely to cause a great deal of trouble during the life of a belt drive.


EDITORIAL ROOMS
Questions Asked and Answered by Readers
Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.
Practical Pete

QUESTIONS

Who Can Answer These?

What Determines Minimum Thickness of Brushes?

I recently tried to eliminate sparking on a d.c. compound-wound generator by reducing the thickness of the brushes from $\frac{3}{8}$ in. to $\frac{1}{8}$ in. This reduced the sparking, but the commutator became so hot that it turned blue. Will readers please tell me (1) what limits the minimum thickness of brushes for d.c. motors or generators, and (2) how can I overcome this heating without using a thick brush which will again cause sparking?
New Haven, Conn. J. R. S.

Parallel Operation of Shunt Generators

I have two 125-volt shunt generators rated at 50 and 125 kw., with 8% and 5% regulation respectively, at rated full load. I want to operate these generators in parallel on a common bus to carry a 165-kw. load. The voltage regulation curve of each machine is a straight line. Will some reader tell me (1) how paralleling can be accomplished safely; (2) what voltage I may expect on the bus and, (3) what the current output of each generator will be at this load?
Chicago, Ill. H. R.

Lubrication of Inaccessible Bearings

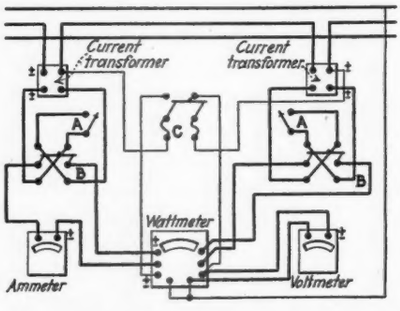
Each of the five very inaccessible babbitted split bearings, which support one shaft that is located in a hot and very dirty place over our boilers, becomes hot and binds on an average of twice a year. The cause of the trouble is probably sometimes due to dirt getting into the bearings and to lack of oil at other times. As it is difficult for the oiler to attend to these bearings properly, I shall appreciate readers telling me how to take care of them so that only one yearly inspection will be necessary.
Ft. Wayne, Ind. H.G.

Effect of Delta Connection on Power Factor of Systems

With a 110-volt, 100-kw. lighting load on transformers of sufficient size, open-delta connected to a three-phase, 2,200-volt primary, has the 2,200-volt circuit a power factor of 0.866, or is this only in the transformers? Would the current be the same in the 2,200-volt circuit, if in one case we have two transformers connected in open-delta and in another case three transformers in closed-delta, the transformers in each case being large enough and equally loaded? What would be the effect on these transformers of a motor load at a power factor of 0.75? Is the fact that more total capacity in transformers is required in open-delta the only objection to their being so connected? W. T.
Port Alfred, Que., Can.

Difficulty in Getting Positive Reading with Test Switches

We use a meter box containing a wattmeter, an ammeter and a voltmeter, for testing equipment. In the cover of this box there is a switching arrangement in the secondary circuit connected as shown in the illustration. When the switches



at *A* are open and the switches at *B* are in the up-position, the meters are connected in accordance with the polarity marks. This connection will not always give a positive reading for each phase, but by reversing the switch on the phase —that is, giving a negative reading— two positive readings are obtained. In some cases, when testing a motor, if the switches are placed to obtain a positive reading when the motor is loaded, one phase will give a negative reading when the load drops off. Will readers tell me which of these readings is correct, and how I should proceed to obtain the correct load and low-load readings? Would the addition of a double-pole double-throw switch in the potential circuit eliminate the difficulty?
Temiskaming, P. Q., Canada. J.H.S.

How Are Foundation Bolts Lengthened?

I have a heavy box-type unit that must be raised $3\frac{3}{4}$ in. above the level of its present concrete foundation. The anchor bolts are firmly imbedded and cannot be removed. Raising the unit this distance will bring the tops of the 1-in. bolts on a level with the bottom of the bed plate that is cast on the box. Will some reader please tell me how I can lengthen these bolts economically and still have a first-class job?
Sudbury, Mass. M.T.R.

ANSWERS

Received to Questions Asked

How Should This Blower Be Driven?

I should like to have the advice of our readers on a drive problem. I have a blower with an 8-in. pulley which will be driven by a 720-r.p.m., 25-hp., three-phase, 25-cycle motor. To obtain the proper speed, if the blower is belted directly with motor, I will have to use a 26-in., cast-iron pulley on the motor. Will this make a satisfactory drive, or would it be better to use a jackshaft to secure the desired blower speed? In this case I could use a smaller motor pulley.
Toledo, Ohio. F. H.

ANSWERING F. H.'s question, I can see no reason why he should use a jackshaft. The 26-in. pulley on the motor running 720 r.p.m. will have a peripheral speed of only 81 ft. per sec. and there is not enough difference in the diameters of the pulleys to cause belt trouble, unless the center distance between the shafts is very short.

A peripheral speed of 85 ft. per sec. is considered perfectly safe, and 100 ft. per sec. is considered safe by some engineers, although this latter speed is about the maximum for cast-iron pulleys.

I am sure that F. H. will find it more satisfactory to use the 26-in. pulley on the motor than to use a jackshaft for this purpose.
Fort Smith, Ark. J. T. ALFORD.

REFERRING to F. H.'s question, the use of large diameter pulleys was discussed in this department on page 86 of the February issue, but doubtless F. H. has seen the answers to this question.

I would advise him to go ahead and use the 26-in. diameter pulley on the motor, being sure that it is well balanced. This pulley will give a belt speed of about 4,800 ft. per min., which is permissible. A light belt should be used in this case to allow it to hug the pulley.

A direct drive from the motor to

the blower would be more convenient, for by using a sliding base on the motor the belt could be tightened at any time. Under these conditions I would recommend a light 5-in. double leather belt, which is ¼ in. to ⅜ in. thick. It should be made endless, if the full 25 hp. of the motor is to be transmitted. This information is based on Taylor's formula and probably calls for a wider belt than would some other tables, but it seems to me that this extra first cost will be more than made up in the longer life and freedom from trouble.

H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

IN ANSWER to the question by F. H., I would say that the 26-in. pulley on the motor may be used, if the center distance is large enough to give a good contact on the 8-in. pulley. Should this distance be too short, however, it might be advisable to install a jackshaft in such a position as to give a good contact on the driven pulley.

Except for this reason, there is no advantage in using the jackshaft, whereas there is the disadvantage of the added friction incidental to driving the jackshaft, although this might be balanced by the desirability of obtaining increased belt contact on the driven pulleys.

F. C. WOOD.

Plant Engineer,
The Heald Machine Co.,
Worcester, Mass.

REPLYING to the question by F. H., I believe that it will be found satisfactory to use a 26-in. cast-iron pulley on the motor, providing the pulley is accurately balanced and the motor bearings are heavy enough to carry the extra weight of the large pulley.

Ordinarily, it is more economical to use as high a motor speed and as small a pulley as the speed and pulley diameter of the driven shaft will allow, for a high-speed induction motor has better efficiency and better power factor than a lower-speed motor. With the 720-r.p.m. motor, a 26-in. pulley can be used, which will give a belt speed of about 4,900 f.p.m. Even though this speed is within the limits of permissible belt speeds, it would be best to use an endless belt in preference to a laced one.

PERCY LAMOTHE.

Smooth Rock Falls, Ont., Can.

IN REPLY to the question by F. H., I would suggest investigating the possibility of changing the motor from four to two poles, which would bring the motor speed down to about 1,450 r.p.m. and require a 13-in. pulley that has a peripheral speed of approximately 5,000 f.p.m. Changing the motor will change its characteristics to some degree, but it is possible to arrange a suitable connection on some types of motors. Another alternative would be to employ the Tex-rope drive made by the Allis-Chalmers Co., which would, I believe prove satisfactory under the unusual conditions found in this installation.

Judging from the question it appears impossible to change the driven pulley; it is possible to drive the unit as it is, but one could hardly recommend this as the best practice.

The use of jackshafts is always practicable but I should prefer a straight drive on this installation, if possible, to attain satisfactory results.

E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Will Two Single-Phase Meters Measure Three-Phase Power?

I should like to know whether two single-phase watt-hour meters can be connected so as to measure three-phase power. If so, will some reader explain the method of connection to use. I have already connected these watt-hour meters in the same manner as is used with two single-phase wattmeters in the two wattmeter method of measuring power. With this connection I find that at unity power factor both meters run at equal speed, while as the power factor gets lower one meter will slow down and the other one speed up until at 50 per cent power factor one meter stops entirely while the other is running at double speed. If the power factor is lowered below 50 per cent the meter that has stopped will reverse and run in the other direction. I wish some one would explain the reason for this, and tell me why the meters are affected differently instead of being affected in the same manner. Specifically, I should like to know what takes place in each meter at unity power factor, at 75 per cent, at 50 per cent, and at 25 per cent power factor.

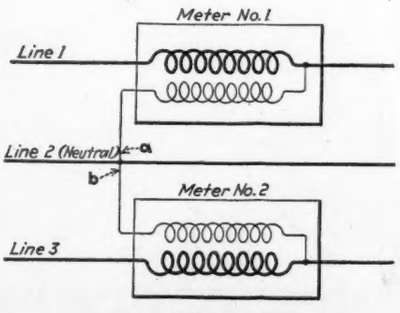
Montreal, Can. W. T.

IN RESPONSE to W. T.'s question, two single-phase meters can be used to measure three-phase power, and this method is used very often in actual practice, as it allows an operating company to stock only single-phase meters.

The usual connection used with a three-phase, three-wire system is to insert the current winding of each meter in a separate line, and connect one end of each voltage coil of each meter to the line in which no current coil is connected; the other end of each voltage coil should be connected to the line in which its current coil is connected.

The accompanying diagram will illustrate how the single-phase meters should be connected. For instance, if meter No. 1 is connected with lead *a* to line *2* and the rotation noted, and lead *a* is then transferred to line *3*, three things will take place: the meter may run slower or faster in the same direction; it may stop altogether; or it may reverse. As a means of checking, this test is usually made with both meters. If, when switching a connection of a meter, it runs slower or faster, but in the same direction, the power factor is between 50 and 100 per cent, and both meters should be connected so that they will turn forward. It very seldom happens that the power factor is exactly 100 per cent, under which condition both meters will revolve at the same speed. With the power factor at exactly 50 per cent, one meter will stand still and in this case the condition is a difficult one to check, unless the power factor is very constant.

Method of connecting two single-phase meters to measure consumption in a three-phase circuit.



The speed of rotation of each meter is proportional to the field, which is proportional to the current times the voltage, times the cosine of the angle between current and voltage. Since at 100 per cent power factor the angular relation between the current and the voltage in each meter is the same, each meter should register the same or revolve at the same speed on a balanced circuit. With a change in power factor, however, there is a change in each meter in the angle between the current and voltage, and as the angle for the meter in which the current lags becomes greater, that meter revolves slower, and at 50 per cent power factor ceases to revolve. So, if the circuit power factor was absolutely constant at 50 per cent, the total energy could be measured by one meter connected to the correct lines. This is, of course, a purely theoretical possibility, since no power factor is absolutely constant. In a similar way, at 100 per cent power factor the total power could be measured by one meter and the reading multiplied by two or a dial train provided to register double the amount actually measured, which condition is also purely theoretical.

Referring to certain specific points brought up in the question, the relative speeds of the two meters, assuming that the total of the two speeds is 100 per cent, will be approximately as follows:

Power Factor	Slow Meter	Fast Meter
100	50	50
75	25.5	75.5
50	0	100
25	—62	162

It may be noted from this table that one meter, the one called slow, will revolve backwards at quite a fast rate at 25 per cent power factor.

C. OTTO VON DANNENBERG.

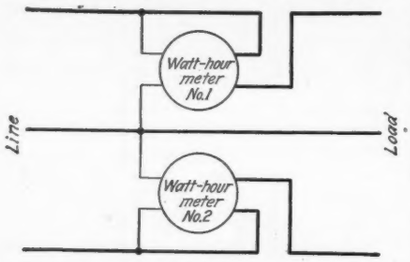
Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

REGARDING the question by W. T., two single-phase watt-hour meters can be used for three-phase, three-wire power measurement, and assuming that the meters are connected correctly, the total power will be the algebraic sum of the two meter readings. If the load is balanced, each of the two meters will indicate half of the power at unity power factor. At 50 per cent power factor, one instrument will indicate all of the power, and the other one will read zero. At less than 50 per cent power factor, the

reading of one instrument will be negative.

The accompanying diagram indicates the method of connecting the two meters to the line, and in doing so the current connections should be checked carefully because, if not correct, one meter may indicate a reading that is as much as 100 per cent in error.

To test the connections, if the power factor is greater than 50 per cent, the rotation will always be forward when either the potential or the current connections of either element are disconnected, although in one meter the speed



These single-phase watt-hour meters are connected so that they will indicate the total power in a three-phase, three-wire circuit.

will be less than in the other. When the power factor is less than 50 per cent, the rotation of one meter will be reversed.

In case there is no power factor meter handy, the meter connections may be made in a way that will indicate whether the power factor is above or below 50 per cent. To do this, connect one meter element to the line, and after noting the speed of the disk, change one potential connection from the middle to the other outside wire and note the disk's speed. If the power factor is over 50 per cent, the speed of the disk will be different in both cases, but in the same direction. When the power factor is under 50 per cent, changing the potential connections will cause the disk to rotate in a forward direction in one case and backward in the other.

GRADY H. EMERSON.
Birmingham, Ala.

ANSWERING W. T.'s question, it is possible to measure three-phase power with two single-phase watt-hour meters; in fact it is common practice to do so. It is assumed, however, that the three phases are balanced as to current, voltage, and power factor. These three factors being equal in each phase, the algebraic sum of the readings of the two meters will represent the total power consumed by the load, regardless of the power factor. However, the two watt-hour meters will read the same only at unity power factor.

As the power factor drops from unity, one meter runs slower than the other until at 50 per cent lagging power factor one meter stops entirely and the other indicates the total power. When the power factor goes below 50 per cent, the low reading meter reverses its direction of rotation. The total power is still the algebraic sum of the readings, however, and the reading of the reversed meter should be subtracted from the reading of the other. In the case of four-dial type integrating watt-hour meters, the dial readings of the one running reversed diminish, rather than increase, as usual.

W. T. has asked what meter readings will be obtained at 100, 75, 50, and 25 per cent power factor. Referring to the accompanying diagrams, let W_1 and W_2 represent readings for either indicating, recording or integrating type meters, connected as shown in Fig. 1, W_1 being in each case the meter with the lower reading. At unity power factor the two readings are equal and the ratio is unity. At 75 per cent power factor the slow meter reads only 33 per cent as much as the faster one. At 50 per cent power factor one meter stops, and at 25 per cent power factor the reversed meter runs about 38 per cent as fast as the other.

The reason for this relation between the two meter readings is the change in the angle between the voltage and current with varying power factor. For example, at 50 per cent power factor the vector relations are such that only one meter registers and that meter indicates the total power. As a watt-hour meter is actuated by the in-phase volt-amperes, the current and voltage in the zero-reading meter circuit must be 90 deg. apart, which fact can be shown mathematically.

When connecting the two meters to the line, two double-throw switches may be used to shift the meters from one circuit to the other, thus affording a means of checking the readings.

JAMES B. HOLSTON.
Commercial Engineer,
Wagner Electric Corporation,
Chicago, Ill.

These diagrams concern the measuring of power in a three-phase, three-wire system by two single-phase watt-hour meters.

Fig. 1 — Method of connecting two single-phase meters in a three-phase circuit.

Fig. 2—Relation between power factor and ratio of readings obtained from these meters.

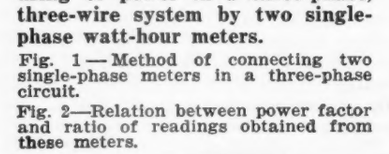
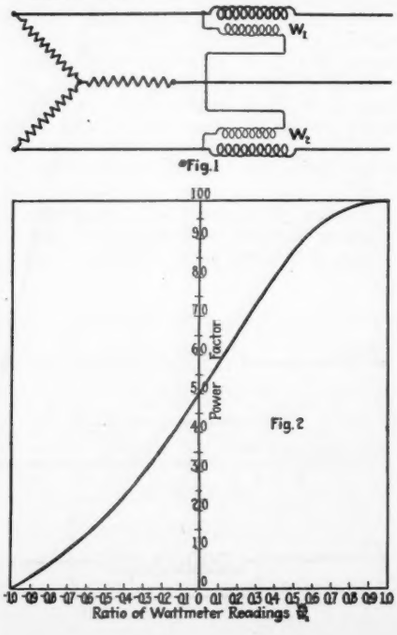
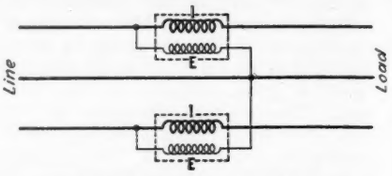


Fig.1



IN REGARD to the question asked by W. T., two single-phase meters can be used to measure the power on a three-phase circuit, if connected as indicated in the accompanying diagram. The current coils of the meters should be connected in two of the wires, and the potential coils should be connected between these wires and the remaining third wire.

The sum of the readings of the two meters is the total energy of the circuit regardless of the power factor or unbalance of load. If the power factor of the circuit is less than 0.5, the negative reading on one of the meters should be subtracted from the reading of the other meter.



These single-phase watt-hour meters are connected to measure energy consumption in a three-phase circuit.

With unity power factor, both meters will register the same, but if the power factor is 0.5, one meter will not register. When the power factor is less than 0.5, the current lag is greater than 60 deg., and the change in the normal phase angle between the current and potential coils in one meter is such as to cause it to run in a reverse direction.

E. A. MILLS.
Superintendent of Power,
Tennessee Copper Co.,
Copperhill, Tenn.

Operation of Electric Refrigerator

Would there be any objection to using brass valves, pipes and fittings, instead of copper, between the compressor and cooling coils of a small electric refrigerator, similar to a household unit, that uses sulphur dioxide as the refrigerating medium? What material is best suited for use as packing and gaskets? What kind of lubricating oil is best adapted for the compressor? What pressures should be carried on the intake and on the discharge when the compressor is running, and when it is not running? What is the best method of charging a unit of this size? I shall be very grateful for any information that readers can give me on these questions.

H. L. M.
Oak, Neb.

ANSWERING H. L. M.'s question, in handling sulphur dioxide (SO_2) the absence of moisture is absolutely essential. When the sulphur dioxide comes in contact with moisture, sulphurous acid is immediately formed on any metal that it comes in contact with. As air contains more or less moisture, it is easy to understand why the refrigerant must be kept in air-tight drums.

Brass fittings are used on several machines at present with apparent success. Brass tubing may be used, but as copper is more readily worked it is preferred to brass. For packing, a good, high-grade, high-pressure steam packing may be used; however, the

manufacturers of these machines have a packing on the market that is especially adapted for this work. Good cork or compressed felt gaskets are used. Also copper asbestos gaskets are used on certain joints. In making the connections, care must be taken to secure an absolutely air-tight job, litharge and glycerine being recommended by one large producer of these machines.

In regard to compressor oil, I believe it would be advisable to secure your oil from some reliable firm that markets a highly treated oil, eliminating any possible chance of introducing excess moisture or foreign substances in the system. I have had excellent results with the Kelvinator brand compressor oils.

When the machine is running, the reading of the high-pressure gage should correspond to the pressure indicated on the accompanying chart. These pressures are minimum values, and the maximum should not exceed these readings more than 4 deg. F. The low-pressure gage will vary as the gas heats and cools. For ordinary house machines the low-pressure gage should read zero when the machine has completed its compression run and should read between 8 and 10 lb. pressure when the machine is ready to start the compression run.

In charging the machine with sulphur dioxide, it is necessary to have a vacuum of not less than 28 in. showing on the gage. This will eliminate most of the air in the system, although it is impossible to draw a perfect vacuum. In order to pump down to the required vacuum the following steps will be found useful:

The discharge valve should be closed completely to the right. Remove plug from discharge valve and open suction valve, so the compressor will pump a vacuum on the system and discharge the air through the opening in the discharge valve. Start the compressor and as soon as the desired vacuum has been drawn, as indicated on the compound gage, the discharge valve should be filled with compressor oil until all bubbles disappear. Connect the drum of sulphur dioxide to the discharge valve by means of a short piece of copper tubing. Before making the connection to the discharge valve tight, the valve on the drum of gas should be opened and enough gas be allowed to escape therefrom to force out the air in the tubing.

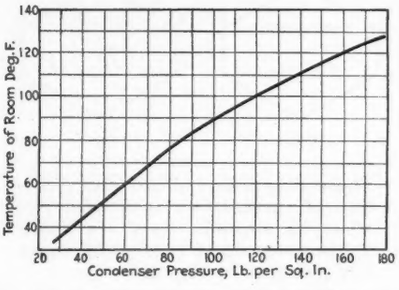
As soon as the odor of the gas is noticeable, the valve should be closed and the connection made tight.

The condenser shutoff valve should then be opened wide and the discharge shutoff valve cracked to the left, allowing the gas to pass into the condensing coils. It is usually necessary to apply heat to the lower portion of the drum of liquid sulphur dioxide to form gas, but too much heat should be avoided. Heating the drum so the hand can be held on it and suffer no discomfort is usually sufficient. When the machine has received the charge, 4 lb. being the average amount for small machines, the discharge shutoff valve is opened wide to the right, the machine is started and the charging connections are removed.

Replace the plug in the discharge shutoff valve and the machine is ready for operation. The oil that was put in the compressor to hold the vacuum will gradually work down into the oil chamber of the compressor, leaving the required working capacity.

It is always necessary to test the machine for leaks after it has been installed. A 28 per cent solution of concentrated ammonia is used in this operation. By dipping a swab in the solution and passing the swab around the connections, a reliable test for leaks may be made inasmuch as a small amount of smoke, similar to cigarette smoke, will be seen as soon as any escaping sulphur dioxide comes in contact with the ammonia.

This temperature-pressure chart indicates the approximate pressures which should be carried on the high-pressure side of ice machines using sulphur dioxide gas.



PHIL D. COMER.

San Bernardino, Calif.

ANSWERING H.L.M.'s questions in order: (1) The objection to using brass valves, pipes and fittings instead of copper in electric refrigerators using sulphur dioxide as the refrigerant is that brass is likely to be porous and thus in time permit the escape of the gas. The expansion valve is sometimes made of brass, but to insure against its being porous it is dipped in tin. Brass unions may be used if they are so designed as to butt and compress the ends of the copper pipe together.

(2) Seal packing and gaskets should be obtained from the manufacturer who supplied the refrigerator. In this way the best material for the service is obtained and the gaskets are ready cut and punched for service.

(3) The lubricating oil used in the compressor of a sulphur dioxide refrigerator must be a first-class, dehydrated oil. It is very important that the oil be absolutely free from moisture, as the presence of water in contact with the refrigerant will result in sulphurous acid which will in time eat away and destroy any metal with which it comes in contact.

(4) The intake pressure of the compressor when running varies with the size and type of machine. Of three small units different in size, but all made by one manufacturer, one operates with 2 in. of vacuum, one at atmospheric pressure and the third has back pressure. Large units for ice cream cabinets have as high as 14 in. of vacuum on the intake. The manufacturer or service man should be consulted in each case. The pressure in the condenser at discharge varies with the temperature.

(5) Most of the small refrigerators now manufactured are delivered in charged condition. If, however, it has been necessary to discharge a unit, it will be necessary to see that all air in the system is removed before recharging is attempted. The procedure is then as follows:

Make up all connections tight. Leave the valves as they were when the sulphur dioxide was discharged, and leave the opening in the discharge shutoff valve open. Put a clean, dry rag over the opening in the discharge shutoff valve.

Start the motor and operate the compressor until a vacuum of 28 in. is obtained. Fill the opening in the discharge shutoff valve with clean, dry compressor oil until all bubbles disappear. All air has now been removed from the entire system and it is ready to be recharged. It will be noted that the suction and condenser shutoff valves have been left open to the left.

Weigh a drum of sulphur dioxide and screw a special charging fitting into the discharge shutoff valve opening. Each drum of sulphur dioxide has a valve connected to it to control the passage of the liquid. The valve has a bushing and ⅛-in. pipe plug in it. Always keep the plug in the valve when not actually using it, as this will assist in keeping any sulphur dioxide from leaking out or any dirt from entering the drum. The charging fitting is a ⅛-in. pipe nipple with an enlarged and machined center, so that it can be handled with an adjustable wrench.

Screw the opposite end of the charging fitting into the ⅛-in. opening in the discharge shutoff valve. Just before the fitting is tightened at this point, open the valve on the drum until you smell the sulphur dioxide plainly, and then close it again. This will drive all air out of the fitting.

Tighten the fitting into the discharge shutoff valve and open the valve on the drum all the way to the left.

Test the joints between the drum and the discharge shutoff valve for sulphur dioxide leaks with ammonia.

Now turn the discharge shutoff valve slightly to the left until the compound gage shows 1 or 2 lb. pressure.

Test all joints for sulphur dioxide leaks with ammonia.

Turn condenser shutoff valve all the way to the right.

Turn discharge shutoff valve to the left about three turns. Note that this operation opens a passage from the ⅛-in. opening through the valve body into the ⅛-in. tubing of the condenser coil. When this operation is performed, you will hear the liquid from the drum rush into the condenser coil until the pressure is equal to the pressure inside the drum.

Heat the lower half of the drum with a blow torch just enough so that you can barely hold your hand on it. This operation will increase the pressure inside the drum so that all the liquid in the drum will be forced into the condenser coil.

Turn the discharge shutoff valve all the way to the left. Close the valve

on the drum all the way to the right. Unscrew the charging fitting from the discharge shutoff valve and from the drum.

Screw a ¼-in. plug into the valve on the drum and weigh the drum. The difference in weight between the drum at this time and when it was weighed before is the amount of sulphur dioxide that has been charged.

Fill the opening in the discharge shutoff valve with compressor oil and screw in the ¼-in. plug.

Start the motor and turn the condenser shutoff valve slowly all the way to the left, controlling the pressure on the compound gage as in a new installation.

FREDERICK KRUG.
Asst. to President,
Porto Rico Ry., Light & Power Co.,
San Juan, Porto Rico.

Rotor Winding of Slip-Ring Motor

I am changing the stator winding of a 35-hp., wound-rotor induction motor from three phase to two phase. Will it be necessary to rewind the rotor of this motor? If so how should I go about laying out the new winding and what form should it take? If it is unnecessary to change the winding, please tell me the reason therefor.

Los Angeles, Cal. B. K. W.

THE following will give B. K. W. some of the information that he has requested: When changing the stator winding of an induction motor of the wound-rotor type, certain changes are required in the rotor winding.

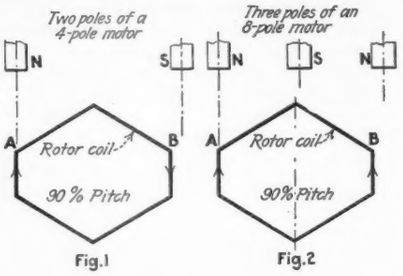
(1) When changing the speed by changing the number of poles, the rotor winding must be changed to have the same number of poles as the stator, which means that if the rotor winding is of the wave type, it must be completely rewound. This statement is based on the fact that in wave windings, as applied to an a.c. rotor, the sum of the back and front pitches must in every case be equal to the total number of slots per single coil divided by the number of pairs of poles. This eliminates any possibility of regrouping for any other number of poles.

If the rotor is of the lap-wound type, it might in some cases be possible to regroup and reconnect for a change in the number of poles. The pitch of the rotor coil will govern the change, and if the stator turns are changed to keep the magnetic conditions normal, the rotor will in most cases be satisfactory. In some cases on lap-wound rotor windings, the coil pitch is chorded to reduce the coil end projections, and for other reasons. The pitch might be full pitch for the new winding or one slot over pitch, which will be satisfactory, as the change in chord factor will have very little effect on the machine's operation from a practical standpoint.

The reason that the rotor coil pitch must be changed to suit the number of poles will be evident after reading the explanations of Figs. 1 and 2 in the accompanying illustration.

Fig. 1 shows two poles of a four-pole motor with a rotor coil that has a 90 per cent pitch. The stator poles in this case are shown as fixed for simplicity. The currents induced in bars *A* and *B*, flow in opposite directions; hence a current will flow in the closed circuit.

In Fig. 2 the number of stator poles has been changed to eight. This change introduces a pole between the two shown in Fig. 1. When the center pole is of south polarity and the rotor coil pitch is left the same as in the four-pole winding of Fig. 1, both sides of the coil shown in Fig. 2 will be under the influence of poles of like polarity, which influence would tend to induce current in bars *A* and *B* in the same direction.



These diagrams indicate the direction of current flow in a rotor coil when its opposite sides are under unlike poles, as in Fig. 1, and under like poles, as in Fig. 2.

Thus, no current would flow and the motor would not operate.

(2) When changing the frequency, if the speed is allowed to vary with the cycles, the rotor winding will be satisfactory electrically, but if the poles are changed to keep the speed constant, then the remarks under (1) apply.

The following stator changes do not require any alterations in the wound rotor:

(1) Increased voltage. (2) Decreased voltage. (3) Two to three phase. (4) Three to two phase. (5) Change in cycles with speed increasing or decreasing in the same proportion as the cycles.

The above five cases hold only when the magnetic conditions in the stator are maintained within close limits of the original conditions. Therefore, the rotor in this case will be as satisfactory when used in the two-phase stator as it was in three-phase operation.

The stator of a two- or three-phase motor will induce an electromotive force in any wound rotor that forms a closed circuit. The number of phases in the rotor will depend upon the mechanical arrangement of the rotor coils and the method of connecting and grouping the coils into a complete winding.

During the early development stages of the induction motor, a number of tests were made to determine the best form of rotor winding. The first step was to select a standard stator and then try out a two-phase wound rotor and take various meter readings. While using the same stator, more tests were run after the rotor had been successively rewound with three-phase, four-phase, six-phase and twelve-phase windings. While checking the pull-out torque, power factor, efficiency, starting torque and other characteristics, it was found that the three-phase winding gave a higher power factor and pull-out torque than the two-phase winding, and that four phases were better than three phases, six phases better than four phases, and twelve phases better than the rest. The power factor and maximum torques improved with the number of rotor phases.

When the practical construction details were considered, the three-phase winding was found to be the simplest, as only three collector rings are required, which number was the minimum, if any were used. An increase in the number of rings and phases requires more brushes and brush rigging and an increase in the length of the rotor in a direction parallel to the shaft.

As a two-phase winding requires four collector rings and four leads and more brushes, and the like, the three-phase winding is superior to the two-phase rotor winding, both mechanically and electrically, and is also simpler than the four, six or twelve-phase rotor windings.

A. C. ROE.
Renewal Parts Engineering Dept.,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

ANSWERING B. K. W.'s question, so long as the speed of the motor remains the same, the rotor can be used on a two- or three-phase line or on any other number of phases without making changes in it. If, however, the speed of the motor is changed, then the number of rotor poles must also be changed.

As there are two kinds of windings on rotors, that is, wave and lap, changes on both types will be explained. First, a wave-wound rotor would have to be completely rewound, to change the number of poles and the coil pitch. The number of circuits and the connection, that is, delta or star, can be chosen for whatever voltage is desired on the secondary. Keeping the coil voltage low is preferable, so as to reduce to a minimum the chance of a breakdown of the insulation.

If the rotor is lap wound, it may be possible to change the coil grouping and reconnect for a change in the number of poles, without rewinding.

The polarity of a three-ring, four-pole rotor reverses four times per revolution and can be used on any four-pole machine, if you want 1,800 r.p.m. when operating on a two- or three-phase 60-cycle circuit.

Newark, N. J. SAMUEL CARBAT.

IN ANSWER to the question asked by B. K. W., a wound-rotor winding is practically always three phase and may be connected either delta or star, depending on the desired voltage between rings. The star connection gives 1.73 times the voltage that would exist between rings if the winding were delta connected. The star connection thus permits the use of smaller rings and brushes, because of the reduced current. On the other hand it requires insulation throughout the windings and collector rings suitable for this higher voltage.

A two-phase winding is practically never used on a rotor, as it would require four collector rings and an added set of brushes.

When the rotating magnetic field is set up by the stator winding, its action on the rotor is practically the same regardless of whether it is induced by

a two- or a three-phase supply. The three-phase rotor has the advantage of requiring a smaller number of rings, holders and brushes.

Carbondale, Pa. WM. MCGUIRE.

REPLYING to B. K. W.'s question, he will not have to rewind his rotor or reconnect it, provided the coil grouping is correct for the number of poles that he intends to use on this motor after changing it to three phase. That is, the rotor of a slip-ring motor should be connected for the same number of coils as the stator. The rotors of two-phase machines are practically all wound three phase, thus eliminating one slip ring and one set of brushes. When a rotating magnetic field is set up in the stator, it will act as well on a three-phase rotor as on a two-phase, and as the three-phase rotor requires one less ring and brush, rotors are usually wound three-phase.

As details of the present rotor winding, that is, whether it is of the wave or of the lap type, are not given in the question, I cannot suggest a way of laying out the new winding. However, the rotor rings could be short-circuited and the machine operated as an induction motor. If this is done, the machine will have a low starting torque and a high-voltage tap of the starting compensator should be used.

Birmingham, Ala. G. H. EMERSON.

Effect of Altitude on Capacity of Generators

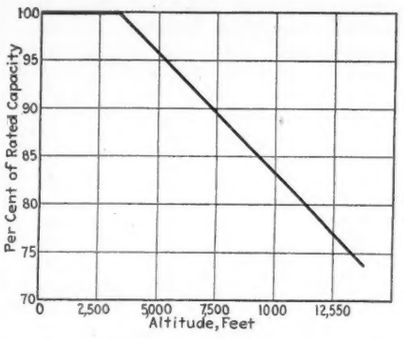
Will some reader tell me the effect of altitude above sea level on the capacity of electric generators? We often contract to install electrical apparatus at altitudes of about 12,000 ft. above sea level and would like to know how much the generators should be derated. The A.I.E.E. Standardization Rules specify derating in regard to temperature guarantees, but we would like to know the equivalent in capacity as expressed in kw. or kva. rather than in temperature rise.

Lima, Peru. A. B.

REPLYING to the question asked by A. B., for several years I supervised electrical equipment of various kinds for shipment to the west coast of South America, some of it going to altitudes as high as 17,000 ft. Consequently, I have collected considerable data on the effect of high altitudes on the operation of electrical apparatus, as well as on other types of equipment.

Rotating electrical machines such as motors and generators are cooled largely by the fan action of the rotating elements of the machine itself, and as the density of air becomes less as the altitude increases, the cooling effect of the air decreases with an increase in altitude. The A.I.E.E. rules state that a decrease of 1 per cent for every 330 ft. rise shall be allowed over and above an altitude of 3,300 ft. In other words, machines are supposed to have enough margin in their heating so as not to exceed their guaranteed temperature rise at any altitude up to 3,300 ft., but for altitudes higher than 3,300 ft. a capacity correction must be made.

From this latter statement, together with the fact that a 50-deg. motor or generator will operate at a 40-deg. C. rise when running at about 83⅓ per cent of its capacity, it is possible to construct a curve similar to the one shown in the accompanying diagram, which will indicate the rated capacity of a motor or generator at different altitudes. This curve may not be absolutely correct, but will serve to indicate about how much the rating of a rotating electrical machine should be reduced so that it will not exceed its guaranteed temperature rise at any given altitude. Of course, this curve will apply only to motors, generators, and other rotating machines, and not to transformers.



This chart indicates the maximum safe working capacity of a motor or generator at different altitudes.

Electrical machines dissipate heat both by radiation and convection. Altitude has very little effect on the radiation of heat. A self-cooled oil transformer loses a larger proportion of its heat by radiation, as compared with a motor, which has the advantage of the fan action of its own rotor. Therefore, an increase in altitude does not affect the rating of a self-cooled oil transformer to so great an extent as in the case of motors and generators. However, in the case of a very high voltage transformer, allowance must be made for the decrease in the dielectric strength of the air at high altitudes. This decrease in dielectric strength also affects other electrical equipment handling high voltages, such as oil circuit breakers, lightning arresters, transmission line insulators and the like.

In the case of transmission wires, it may be necessary to space these farther apart in order to reduce the corona loss. I believe it will be found that a transmission line built for 110,000 volts at sea level might have to be designed for 180,000 volts if operated at an altitude of 12,000 ft.

R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

IN REPLY to the question by A. B., altitude has considerable effect on the capacity of electric generators, owing to the variation in density, heat conductivity and dielectric strength of the air. Up to altitudes of 750 ft. there is not much difference in the capacity of generators, but from this height up to 3,000 ft. slight changes are necessary in the generator, when it is desired that its capacity be about the same as it normally would be at sea level.

Machines to be used above 3,000 ft. are regarded as special-duty machines, and a correction factor should be used. For high altitudes, allow 1 per cent decrease in the capacity output of the generator for every 330 ft. above 3,000 ft. In A. B.'s case the capacity of a generator would be decreased (12,000 — 3,000) divided by 330 or 27 per cent at an elevation of 12,000 ft.

W. E. WARNER.
Shefford, Bedfordshire, England.

ANSWERING the question by A. B., during a period of three years spent in installing and maintaining electrical apparatus at altitudes from 9,000 to 12,800 ft. above sea level, I assembled some interesting data regarding the effect of altitude on electric apparatus. Generally the effect of altitude on electrical apparatus is not so evident at points below 9,000 ft. as above that elevation.

With d.c. generators and motors, I have found that heating at high altitudes can be reduced to a point within the manufacturer's guarantee, if the rated capacity is decreased about 1 per cent for every 300 ft. of elevation. For example, in order for a generator to deliver 50 kw. at an elevation of 12,800 ft., its sea level rating should be: $50 + [(12{,}800 \div 330) \times 0.01 \times 50] = 70$ kw., approximately. This checks fairly well with the A.I.E.E. standard, which would be, in this case,

$$50 + [(12{,}800 - 3{,}300) \div 330 \times (0.01 \times 50)] = 65 \text{ kw., approximately.}$$

This increase in the horsepower rating of d.c. equipment is satisfactory from the standpoint of overheating because a dangerous heating point is not reached, but from an economical standpoint the cost per horsepower is naturally increased. In addition, there is frequently a tendency on the part of the operator to run the equipment at its normal nameplate rating, in which case its temperature would soon rise above the safety point.

When an a.c. motor is under-rated, for the purpose of eliminating the danger of overheating, there is also a tendency to load up the motor to its sea level rating. On the other hand, if the motor is loaded in accordance with its reduced rating, trouble is encountered with low power factor. It is seldom, if ever, that the purchaser of equipment for high altitudes will install both an oversized motor and the necessary condensers to improve the power factor.

After all, it seems to me that the most economical way of dissipating the heat of electric motors and generators at high altitudes is by means of forced ventilation. With this method special ventilators can be made to suit the equipment for the particular location or altitude in which the apparatus will be operated.

As for transformers, I would suggest a slight change in the A.I.E.E. standard to conform with the following example: Assume that a transformer is to develop 450 kva. at an elevation of 12,800 ft. By increasing the 450 kva. capacity by 0.5 per cent for every 330 ft. above 3,300 ft., the actual

rating of a transformer necessary to carry the 450-kva. load at an elevation of 12,800 ft. should be $450 + [(12{,}800 - 3{,}300) \div 330 \times 0.005 \times 450] = 515$. In this case a standard 500-kva. transformer would have sufficient capacity for the service assumed in this particular example, but the rating of a standard 450-kva. transformer would not have to be increased if a special casing were fitted to it in order to provide a larger area of surface exposed to the air for dissipating the heat. Increasing the area of the casing is generally economically desirable, and in this case there is less chance of overheating when the operator loads the transformer up to its nameplate rating.

In order to avoid the excessive heating and blowing of fuses, at high altitudes, it is necessary to use fuses with larger shells than would ordinarily be used for the same rating.

High-voltage equipment should be selected that has a voltage rating considerably above the actual line voltage. The correction factor, F, that would apply in this case may be determined from the following formula:

$F = 1 + (\text{Altitude above } 3{,}300 \text{ ft.} \div 32{,}600)$. To illustrate the application of this factor we will assume that 44,000-volt apparatus is to operate at an elevation of 12,800 ft. Then

$F = [1 + (12{,}800 - 3{,}300) \div 32{,}600)] = 1.291$. The rated voltage of the equipment should be $44{,}000 \times 1.291 = 57{,}000$ volts, approximately, so it would probably be necessary to use 66,000-volt equipment. MARTIN G. LANE.

Electrical Engineer,
Sego, Utah.

Locating Trouble in Conduit Wiring

We have an extensive system of conduit wiring in our buildings and underground, which takes care of 440-volt power and 110-volt lighting service lines. This system was installed several years ago, and since then certain changes and additions to the plant structures have rendered long sections of the conduit very inaccessible. At various times faults have occurred in the wiring which were very difficult to locate. I wish some of the readers would tell me the best methods of locating grounds and shorts, and also suggest the best ways of testing and checking the condition of the wiring, so that we can detect and locate weaknesses before they become serious.
Providence, R. I. G. F. H.

THE question asked by G. F. H. can be answered by citing a method of procedure for testing out lines installed in conduit. These tests can most conveniently be made when the entire plant is shut down, as on holidays when the power is cut off and all the switches, fuses and circuit breakers are disconnected.

The equipment that is used for this testing work frequently consists of an insulation test meter complete, or a high-grade voltmeter that will indicate readings from 0 to 5, 0 to 50, and 0 to 150 or 200 volts. Preferably there should be a terminal provided that will permit millivolt readings to be taken. The test current can be provided by one or more blocks of standard radio B batteries.

When these are connected, the total voltage should not exceed the limit of the scale on the voltmeter. Several cable test leads should be made up into different lengths ranging from 8 to 10 ft., each of which may be distinguished by the color of its braid or covering.

The procedure to be followed in testing out cables will be given only briefly here, for it is frequently necessary to modify the procedure to suit local conditions, although the principle of these methods should be based on the one to be described.

Let us assume that a metal conduit contains three cables, X Y and Z, the ends of which are disconnected from any other circuit or device such as circuit breakers, potential transformers, and so on.

Date _____

Run No. _____ Cable No. _____
From _____ Box No. _____
To _____ Box No. _____
Circuit No. _____ No. of Cables _____
Size of Cables _____
Voltage _____ Amp. (Full Load) _____ Insulation _____

Test Between Cables		Applied Test Voltage	Voltmeter Reading	From Box	Remarks
X	Y	100	30	P10	Box P9 gave 20 volt readings, leak nearer Box P10
X	Z	100	30	P10	
X	Grd.	100	30	P10	
Y	Z	100	30	P10	
Z	Grd.	100	30	P10	
Y	Grd.	100	30	P10	
N	Z	100	10 Millivolts	P10	Copper dust between switch blades — removed, tested OK.

Other data may be recorded on back of this card

How to keep a record of cable tests

To test for a short-circuit between the cables, first connect the positive lead of the 100-volt battery to cable X, the negative battery lead being connected to the negative voltmeter terminal that is connected to the scale having a range from 0 to 150. The positive voltmeter terminal we will assume is connected to a red colored test lead that is also attached successively to the lugs of cables Y and Z. If no voltmeter reading is obtained, cable X is insulated at all points from cables Y and Z. Sometimes, however, a film of carbon or dust between the fuse clips, or a metallic vein in the slate or marble slab of a switchboard, may cause a reading on the voltmeter. However, oil-soaked insulation, dirt and dust are the most common causes of a deflection of the meter when the cables themselves are properly insulated from each other in conduit installations.

If after removing all possibilities of current leakage around the fuse clips there is still a voltmeter deflection, make a good electrical contact between the red colored positive voltmeter lead and the conduit. If when the other meter lead is connected to one end of cable X there is a reading of 20 between the cable and the conduit and when connected to the opposite end of X there is a reading of 30, we would naturally assume that the ground is nearer to the end of the cable where the higher reading was obtained. This assumption is not true at all times because the electrical circuit through the conduit may not be continuous—there may be sections of fiber or clay between the joints.

Most likely current leakage to ground is due to one of the following causes: oil or water in the conduit; deterioration of the rubber insulation; injury to the cable caused by vibration of machinery, or when it was originally installed.

As the voltmeter readings indicated that cables Y and Z were also defective, a reading should be taken between them and the ground. If readings are obtained from these two cables to ground, the trouble is probably due to one of the first four causes mentioned in the previous paragraph. If the trouble is due to water, a good supply of compressed air forced through the conduit may help to determine this point. The voltmeter reading may become less as the water is blown to another part of the conduit. As steady and irregular deflections of the needle tell different stories, the proper use of the air hose may materially assist in determining the cause of the trouble. The compressed air used should be dry and warm, otherwise more condensation may be formed in the conduit, which is not desirable.

In some cases compressed air and talcum powder have helped materially in locating splice boxes, manholes, and panels that were not thought to lie between the main panel and the distribution box. I have mentioned this test because in some plants no record has been kept of the original layout or changes made in the system and naturally a new maintenance force in the plant could not be expected to be familiar with the layout of the conduit in isolated places.

The lower voltage scale of the voltmeter as well as the millivolt scale will be found useful in checking slight, high-resistance leaks. Exceptional care should be exercised, however, in the use of the low-voltage tap when a high-voltage current is being employed for test purposes.

When a cable is tested, a record of the results should be made. A record card suitable for this purpose is shown in the accompanying illustration.

These tests cannot, of course, be made while the circuits are alive, so particular care must be exercised to make certain that no current is on the line being tested. If it is desired to test live or hot cables, other methods must be employed, but in the writer's opinion these tests would be less accurate than the one just described. One very important feature of these tests is that they will show up insulation leaks that have not, so far, proven very serious, and this I believe is the information that G. F. H. desires.
Tampa, Fla. ALBERT J. FIESS.

WITH reference to the question by G. F. H., I would advise him to discontinue the installation of long runs of conduit where they are not accessible and substitute short ones with plenty of junction or pull boxes located at points where a workman can tap the line for testing and repair purposes.

Much, which may be of little value, can be said on paper but my experience tells me that too many junction boxes in a conduit run are preferable

to too small a number. If the boxes are arranged in a run so that the conduits are in line the wires or cables can be run straight through those boxes in which splices are not necessary. Later the boxes may be useful in cutting in new branch conduit lines.

G. F. H. states the conduit system in his plant is quite extensive, and I can realize that additions have made it a network of wires and cables. However, there are on the market conduit fittings that require no threading of the conduit for their installation and which, especially in old or extensive installations, are very easy to install, saving time and labor. For instance, if it is necessary to cut in on an existing conduit line to install a fitting, it is only necessary to cut out a section of conduit about the length of the fitting to be installed and then slip the fitting over the conduit. After securing the fitting to the conduit, the job is finished. The principal advantage of these conduit fittings is that it is not necessary to remove, thread, and replace long sections of conduit.

When it is necessary to make a change on conduit that is in use, temporary wiring can be shunted around the part of the line being changed, and after the work is completed, the line can be re-connected. In this way shorter conduit runs, which will greatly facilitate the testing of the lines and the removal of defective wiring when occasion demands such procedure, can be made.

Trouble in conduit runs is, at times, hard to locate, and the installation of short sections of conduit will make testing much easier. It is often advisable to make periodic tests of all conduit wiring by means of an insulation resistance tester such as a Megger. Complete information covering the use of a Megger can be obtained from the manufacturer, James G. Biddle, Philadelphia, Pa. These instruments are also very useful for testing many kinds of electrical equipment.

When it is desired to build a tester for locating faults in conduit wiring, I would suggest that some form of a Wheatstone bridge be used.

NATHANIEL W. BLANCHARD.
Inwood, L. I., N. Y.

ANSWERING G. F. H.'s question, to test conductors in a conduit for grounds, disconnect both ends of the circuit. If alternating current is used the system should be permanently grounded. Connect the switchboard end of each conductor to the source of current. Then the opposite end of the circuit is ready for testing with a voltmeter, or test lamp, by placing one of the instrument leads firmly on the conduit, while the other lead makes firm contact with the end of the conductor that is being tested. After making a test, be sure to mark the conductors that have been tested. Test all the conductors in the same circuit in a similar manner. If test lamps are used, two 250-volt carbon lamps connected in series will show up a ground by burning very dimly.

Short-circuits on 440- or 550-volt lines usually leave telltale marks, but by testing one pair of conductors at a time at each junction box or condulet, you will be able to locate the part of your system that is giving trouble. It is advisable to see that all joints are both mechanically and electrically secure whenever splices are made in junction boxes.

If the conductors have sufficient current-carrying capacity to handle the load without heating, the possibility of water condensing and lodging in the lower part of the conduit system should be looked for.

As for checking the condition of the wiring in conduit, it seems to me that generally the only safe way to make a positive check would be to withdraw the wires from the conduit for inspection, but unless the amount of trouble experienced warrants such a procedure this work would be unnecessary and expensive.

Belts that run close to conduit or pipe lines will sometimes cut into these in a short time. I might add that conduit work properly installed and held rigidly in place seldom needs attention.

JOHN J. LYNCH.
Engineer,
J. T. Slocomb Co.,
Providence, R. I.

Does Magnetized Shaft of Motor Cause Bearings to Overheat?

We have a 40-hp., compound-wound, d.c. motor driving a horizontal resaw in a lumber mill. The motor is on the lower floor and the resaw is directly above it on the second floor, with practically a vertical pull on the belt. Some time ago the commutator end bearing ran hot enough to melt the babbitt slightly. The end bell was taken off, and the bearing scraped and pronounced perfect, but it still continues to heat. The bearing on the pulley end of the motor remains cool and gives us no trouble. I notice that the armature shaft and frame of the motor become very strongly magnetized when the motor is running. Would this have any effect on the temperature of the bearings? I shall appreciate it if any of the readers will tell me what is causing the overheating of the commutator end bearing, and should also like to know what causes the armature shaft to become so strongly magnetized.

L'Anse, Mich. H. W. S.

REPLYING to the question by H.W.S. I will explain how one of our motors was tested out for trouble of a similar nature.

First, test all of the field poles to see if they are alike in resistance, for this is where the trouble is likely to lie. One or more field coils may be shorted, or partly so, making an unequal pull on the armature toward one side of the frame. This radial pull may cause the bearing to get hot. Should the fields be of unequal strength, this condition should be corrected. If the bearing is worn a little, or is not perfectly centered, and the armature has no equalizer, this will also cause a bearing to heat. However, I am inclined to believe that my previous suggestions are more logical, for evidently this motor has been running satisfactorily in the past.

The machine I have in mind that gave me trouble was a 10-hp. motor and it was the commutator end bearing that got very hot, but as the bearing was of bronze it did not melt. One day I noticed that my watch was affected by this bearing and upon close inspection discovered that the bearing was very strongly magnetized; so I put a ⅛-in. fiber piece between the frame and end shield, holding the end there with a large wooden clamp so as to insulate the magnetism. After all this trouble I discovered that while this bearing ran cool the other end bearing got hot. I decided to test the fields with the result that one was found to be very weak. Some of the tape was taken off the coil and it was found that seven-eighths of it was shorted. After this coil was properly insulated, we had no more bearing trouble.

Chicago, Ill. CHAS. REICHENBACH.

IN REPLY to H.W.S., it is possible that the magnetizing of the frame could be held responsible for the hot bearing, for an electrolytic action may have taken place. This electrolytic action would have a tendency to pit the bearing, making it rough, and thereby causing it to heat. Before accepting this theory, I would make an exhaustive mechanical inspection to locate the cause of the trouble and would also use instruments for the purpose of locating any magnetic leakage.

The insulation of the machine may be checked for grounds with a Megger, and if a low-value reading is obtained, it would indicate that the insulation is defective at some point. In this case the trouble should be located and remedied.

E. J. MORRISSEY.
Chief Electrician,
United Gas & Electric Co.,
Aurora, Ill.

IN REPLY to H. W. S., the overheating he has experienced may be due to a fault in the commutator or armature core, this heat being conducted to the bearing, and sometimes this heat is great enough to cause the mica end-cone plates to become charred.

Another possible cause of the bearings heating may be due to insufficient end play of the armature, in which case the armature would be unable to run in the magnetic center of its field. The armature generally hugs the bearing next to the commutator, and to test for this action of the armature while it revolves, push the armature shaft with a piece of wood toward one bearing and then the other. If while pushing the shaft toward the commutator bearing it is found that there is no clearance on that end, some metal must be filed off of the collars on the armature shaft, or off the bearing in order to allow more play at the commutator end of the shaft. When the armature is running properly, it should float between the bearings without having a pronounced tendency to hug either bearing. Then again the hot bearing might be slightly out of line with the shaft.

In my opinion a magnetized shaft would not cause this heating, for the commutator end bearing should not heat any more than the other one at the pulley end, unless there is heating at the commutator. In this case it might be advisable to test the machine for proper electrical connections and insulation.

W. E. WARNER.
Shefford, Bedfordshire, Eng.

Electrical Service

AROUND THE WORKS

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Inferior Grade of Insulation Cause of Trouble

IT SOMETIMES happens that the conducting material in slate or a poor grade of impregnated insulating paper stock will cause trouble that is not easy to locate.

For instance, in reviewing the test results covering the accuracy of a three-phase, three-wire watt-hour meter, it was noted that one of the elements when tested alone was apparently registering more that it should; in other words, the element was running fast. There had been no complaint regarding incorrect registration from the customer, but the matter was investigated to anticipate possible future trouble.

A check indicated that the tester's results were approximately correct; so a further search was made. The meter voltage coils were connected directly to a 550-volt circuit, being protected by three fuses on slate bases, one connected to each outside line, and the third to the middle lead that served as a common connection to the two voltage coils. It was noted that when the two fuses to the outside lines were removed, the meter still continued to revolve, and consequently power was being registered.

Purely by accident, as darkness came on, some glowing spots were noticed in the slate on which the holders for one of the outside fuses were mounted. The removal of the slate bases, which were replaced by fuse holders on porcelain bases, solved the mystery. A test of the defective base showed that the slate heated very markedly when the full voltage was applied to the terminals for a comparatively short length of time.

At another time, a case of trouble caused by defective switch material developed on a three-pole knife switch operating at 440 volts. The three blades were connected by an insulating yoke to which the operating handle was attached. Smoke was seen rising from the switch when it was carrying practically no load.

When an investigation was made, the yoke was found to be so hot that it was impossible to hold one's hand on it. After the defective yoke was removed, it was discovered that it had been made of impregnated paper stock made from old newspapers and waste paper, which required bleaching before impregnation. The material had evidently not been thoroughly washed after bleaching, and when pressed into the form and impregnated it contained a sufficient amount of conducting material to cause it to heat.

The discovery of this defect gave the explanation to a previous case of trouble when a similar switch became short-circuited without apparent reason.

C. OTTO VAN DANNENBERG.
Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

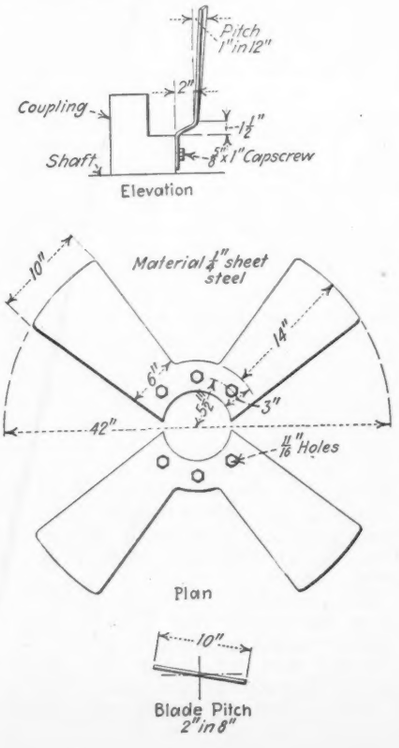
Use of Auxiliary Fan to Keep Overloaded Motor Cool

IN A local brick plant one of the tile machines is driven by an early model Westinghouse 440-volt, wound-rotor motor with a rating of 125 hp. at 600 r.p.m. This motor which is connected directly to a speed reducer through a flexible coupling, is heavily overloaded. In order to keep the temperature of the motor down, the plant engineer designed a fan which is mounted on the hub part of the motor coupling and it has been very effective.

As will be seen from the illustration, the fan was made in two parts from ¼-in. sheet steel. The two halves were roughly cut to shape with an acetylene torch, allowing enough stock for finishing, after which the offsets and pitch of the blades were put in by the blacksmith. The inclination of the blades toward the motor frame, as shown in the side view, was made 1 in. in 12, and the blades were given a pitch or twist of about 15 deg. from the face of the coupling. The plan view shows how the two halves were fastened by capscrews in tapped holes in the coupling, which placed the fan outside the motor frame, between the end bearing and the coupling. A sheet-steel guard is fastened in a circle around the blades, allowing about 1½ in. in the radius for clearance.

In this position the fan serves not only to keep the motor cool, but also to keep it clean, and every operator knows that clean insulation prolongs the life of electrical machinery. Cool air is pulled through the motor from a large doorway, instead of blowing it through the motor from the tile machine side where considerable dust is encountered from the distributor and the pug mill. The fan could, no doubt, have been made of lighter material with safety, eliminating the necessity of balancing the rotor. In some motors there may be sufficient room to install such a fan inside the motor frame, thereby doing away with the guard.

The fan was constructed as shown in this diagram, and fastened to the motor coupling.



Disadvantage of Supplying Several Departments from One Feeder

ONE morning our office was notified that a motor was "down" at a certain stove foundry, so I went over to iron out the trouble.

The foreman of the rattler room met me at the gate of the plant. The rattlers in his department were used for cleaning the castings before grinding. As the castings have a great deal of sand on them and the cleaning creates dust, an exhaust fan had been installed in one corner of the building, with an exhaust pipe connected to each rattler.

The foreman told me that his exhaust fan would run slowly, but would not come up to speed. The fan motor was a 15-hp., three-phase, 220-volt machine, belted to the fan. When the belt was removed, the motor would run slowly, but would not come near full speed, which was 1,800 r.p.m. The line was tested and it was found that there

was power on all three lines, but the voltage seemed to be low across one phase. The fuses were then removed and found to be good. The main fuses, which were located some distance from the motor, were examined and one was found to be blown. After this fuse was refilled, the motor was started again, and another fuse blew out. We examined the motor bearings, and as they seemed to be too low, they were replaced with new ones.

In the meantime the main fuses had been refilled again and when we were ready to test the motor out, another fuse had blown, although the motor had not been running; so we then set out to determine what had caused the fuse to blow while we were working on the motor.

The circuit supplying this motor was also a feeder to the nickel-plating room, and the head of this department soon came over with the complaint that none of his motors would start—they would only hum. We asked him not to try to start any motors for a while, and in the meantime the fuses were refilled. We then tried the fan motor in the rattler room, and found that it now operated satisfactorily. So I then went to the nickel plating room and personally started the motors, but found that one would not start, for when I threw the starting switch to the running position, the fuses blew.

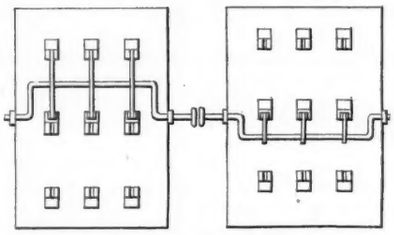
Thinking that the cold weather had caused the grease in the grinders and buffing wheel bearings to harden, I had the men pull on the belts after starting, but even then the motor would not run. Later I asked them to pull on the belts, and this time I noticed that the belt of one grinder would slip on the pulley before the grinder would turn. After this belt was removed, the motor started readily. As soon as a millwright had removed the grinding wheels, the shaft revolved freely. When the wheels were replaced, the shaft would not revolve. The wheels were removed again and it was found that the shoulders on the shaft were so rounded and worn that the wheels had been pulled up against the grinder bearings, instead of against the shoulder on the shaft. As the nuts were made so that they had a tendency to tighten, the wheel shaft could not turn. Since the bearings had been rebabbitted, they were very tight, so they were scraped and after special washers were placed on the shaft for the wheels to tighten against, the trouble was eliminated.

The reason for the fan motor starting and running with a blown main fuse was because current was fed back in the blown fuse line through the windings of the motors in the other departments. If these motors had been sufficiently large, the fan motor would probably have attained full speed. The other motors that were already running might have burned up or got hot enough to smoke, if they were loaded sufficiently and run long enough.

My experience at this foundry shows that when two or three departments are connected to one feeder, trouble in one department may cause delays in all of them. In the above case, if the motors had been connected to individual circuits, the trouble could have been located much sooner.

GRADY H. EMERSON.
Birmingham, Ala.

One Emergency Application of Enclosed Safety Switches

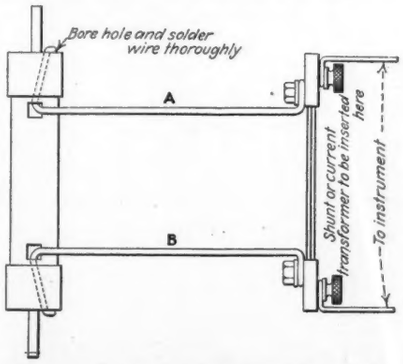


The accompanying sketch shows how a double-throw switch was made in an emergency. In this particular instance two similar enclosed triple pole single throw fused safety switches were mounted side by side. The handles were fastened together with a cable clamp which connected the two switches mechanically so that when one was in the open position the other was in the closed position. W. T. STEVENS.
New Westminster, B. C., Canada.

Simple Method of Cutting Meter Into Circuit

QUITE often it is necessary for the plant electrician to measure the amperage of a motor or of a circuit. In such cases there is seldom a handy place for cutting in a measuring instrument on the line. So I have adopted an arrangement that will allow either a direct-current or an alternating-current ammeter to be readily connected to the desired circuit. This is accomplished by cutting in a shunt for direct current, or a current transformer for alternating current at the fuses protecting the circuit.

First of all, several different sizes of fuses can be salvaged from the fuse junkpile. My last collection of such fuses included four sizes, 30-, 60-, 90- and 150-amp., for operation on a 600-volt circuit. Holes should be cut in the fiber at each end near the ferrule, as shown in the illustration, to accommodate wire of ample size to carry the current. After the wires have been soldered into the holes in the ferrules, the excess copper and solder projecting through the ferrule should be filed off.



The test circuit leads are connected to the ferrules of blown fuses which are temporarily inserted in place of the fuses protecting the equipment.

When it is desired to measure the current in any circuit or in any particular motor, only a few moments are needed to remove the fuses protecting the circuit, insert the blown fuses with wires attached, connect the ammeter, and then close the switch.

For a d.c. line a shunt is attached to wires *A* and *B*, as shown in the illustration, and for an a.c. line a current transformer is attached to these test wires. If it is desired to use a graphic wattmeter, two such blown fuses are employed.

When the test fuse connectors are not in use, they take up but little space in the shop; on the job they are real time-savers. CHAS. A. PETERSON.
Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Overheating of Two Motors Due to Overload

ALMOST unusual trouble came to my attention a couple of years ago when, in my capacity as road man for a large electrical manufacturer, I was sent out to investigate two motors driving a disintegrator, that were heating.

The installation was new and had been hastily put in, with the usual result that a poor job had been done.

I found that the motors became hot after running only 20 min., in fact that the insulation had been injured from the numerous attempts to get them functioning correctly. An investigation showed that in the terminal box of the smaller motor the insulation, which consisted for the most part of a single layer of friction tape, had broken down allowing the 220-volt circuit conductors to short through the terminal box. Further inspection was held up by the purchaser who said he could have his contractors correct this trouble, but on my recommendation he requested that I make a more thorough examination when the contractors had completed their work.

Reinsulating the motor leads did not help, as both motors still heated badly. So I checked the supply voltage and all connections, and found them to be correct.

Finally, I obtained some instruments from the local public service company and ran a test on the installation, with the result that I found the 30-hp. motor was taking 38 kw. with the disintegrator running empty, whereas the 40-hp. motor had 50 kw. charged against it under the same conditions.

Subsequent investigations proved the results of my test. This was the first attempt of the disintegrator manufacturer to use direct-connected motors, former installations being belt driven. These motors were later replaced with 60- and 75-hp. motors respectively and no further trouble was encountered.

The usual tendency is for manufacturers to use larger motors than are required on their machines. However, this case was an interesting exception.

E. J. MORRISSEY.
Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

MECHANICAL MAINTENANCE OF *Power Drives*

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Method of Mounting Countershaft to Allow Easy Adjustment

ALIGNMENT of a countershaft with the machine it drives is sometimes accomplished with considerable trouble, especially where the shop is crowded and a machine must be placed where there is room instead of where it should be. Countershafts to screw machines, which are usually set in staggered formation, often present difficulties of this nature and so do other machines in which the belt is twisted. For this reason the commendable practice of fastening machines to wooden blocks imbedded in the cement and thus having some adjustment, instead of fastening them down by bolts set in the concrete, is more and more coming into use. However, even this is not always adequate, and it is frequently necessary to resort to the laborious job of moving the countershaft.

One way to sidestep troubles of this nature is shown in the accompanying illustration. This method is as simple as it is easy, inexpensive and effective; also, it has good points beyond facilitating the adjustment of the countershaft, which was the main object. The plan consists of suspending the entire countershaft assembly, mounted on the wooden stringers, from two or three stout steel plates hung from a timber placed crosswise over the top of the available ceiling construction.

For the countershafts in question, which were for Nos. 00 and 2 B. & S. screw machines, ¼x4-in. machine steel plates were used. The plates were placed as close to the hangers as possible and fastened in place on the wooden stringers by a stout screw in each. On larger machines 4x6-in. wooden blocks were used instead of the steel plates and a timber of a similar size was used above the overhead structure. Two ¾-in. bolts, as shown, extended up through the steel plates into this overhead timber.

A countershaft fastened in this way costs comparatively little, if any, more than by the usual method of lagscrewing it fast. Adjustment relative to the machine, instead of being the usual cumbersome and difficult job, is reduced to a trifling matter of loosening the two nuts on the ¾-in. bolts, tapping the countershaft assembly until it is aligned properly and retightening the nuts.

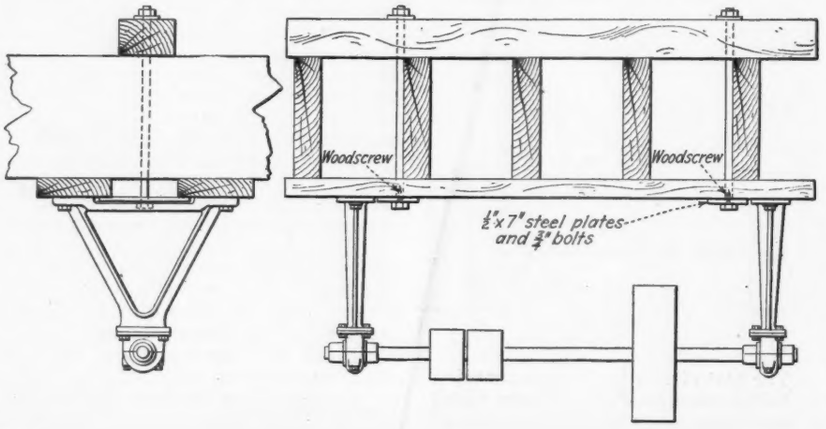
This mounting is as rigid as if the assembly were held to the ceiling by a number of lagscrews. If necessary, the countershaft can be mounted at an angle to the ceiling timbers instead of crosswise. Where no obstructions are in the way, the assembled countershaft can be moved a considerable distance in the direction in which the joists run.

The stringers as well as the beam should be cut long enough to allow the countershaft to be shifted crosswise of the joist by the distance of one space, which will ordinarily be from 10 to 14 in., and the plates should be so placed as to allow as much as possible of this distance to be utilized for adjustment. In the illustration it will be noted that the countershaft has been shoved about as far to the right as possible, but it can still be moved 6 or 8 in. to the left.

Jena, Germany. HENRY SIMON.

This countershaft can be shifted until aligned before fastening.

The assembled countershaft, mounted on stringers, is held up by the long ¾-in. bolts extending from the steel plates through a 4x6-in. beam above the joists. In this way the countershaft can be shifted a considerable amount by loosening the nuts and tapping into position. Tightening the bolts will hold the countershaft in position, although a lagscrew or two through the stringers and into the joists may be added if desired.



Method and Tool Used to Reface Surface of Fiber Pulley

ONE of the early installations of motor drive in an Eastern city was that of a fabric-manufacturing plant that had put in a 125-hp. dynamo, which was driven by a Corliss engine, to furnish power for the motors. They called them "dynamos" exclusively then and rated them by horsepower instead of kilowatts. After running 28 yr., six days a week, it became advisable to turn off the surface of the pulley on this dynamo.

This was one of the familiar paper pulleys used on electrical machines and it had been on during all this time the dynamo had been used. The 20-in. belt had worn grooves near the edge as well as wearing the surface somewhat out of round. The pulley was 23x23 in., with 3½-in. bore.

No mandrel was available for turning the pulley; nor was any bar steel handy large enough from which a soft mandrel could be made. The possibility of making a casting and using it for a mandrel was discussed. Finally the venerable millwright made the suggestion that a stick of hickory in the storage shed could be used for the mandrel.

Accordingly a piece 3 ft. long was cut and roughly shaped with a draw knife. Then carefully drilled ⅝ in. centers were put in each end. These centers were soaped and the stick was turned and fitted as a mandrel. Later the pulley was turned down and recrowned by using this same wooden mandrel.

The tool used was a high-speed steel bit held in an ordinary holder. The slant of the tool holder gave the tool about the proper top angle, or rake, for good cutting. The tool was ground far back underneath, giving it about four times the clearance angle of metal-cutting tools and approaching the included angle of the wood turner's chisels. In general, this keen tool was formed like a regular round-nosed metal-cutting tool or bit. It was set

about 3 in. above the center of the fiber pulley. (On a smaller diameter it would not have been so much above the center of the work.) The object was to produce a tool that would cut freely because it was keen and placed at the easiest cutting angle. With a material not possessing the strength and resistance of metal, it is necessary to adopt means that will cut without tearing the fibers.

The tool, at best, cannot be expected to leave a presentable surface. No. 1 sandpaper tacked to a piece of board of considerable width was then used to smooth off the turned surface.

Instead of coating the turned surface with paint or shellac, the manufacturer recommended a finish of belt dressing. This was applied by holding stick dressing against the pulley as it revolved in the lathe. The heat sufficed to spread an ample amount on the pulley. After placing in service, the lapping of the belt very soon imparted to the treated pulley a fine smooth finish quite like that on a new pulley.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

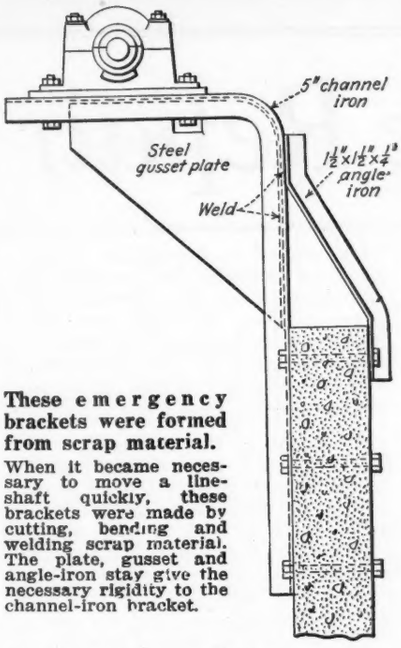
Emergency Bracket for Mounting Lineshaft on Pit Wall

WHILE engaged in some plant extension work, I had occasion to change the location of a lineshaft from a position in front of a concrete pit wall to a position directly over the edge of the pit and about 1 ft. above the wall. There being no wall brackets available, it was necessary to construct something that could be fastened to the wall and at the same time support the shaft.

After looking over the material on hand it was decided that a suitable bracket could be constructed from a number of short pieces of 5-in. channel iron for which we had no other use. How this was done with the aid of a cutting and welding outfit is shown in the accompanying sketch. The pieces of channel iron, which were 4 ft. long, were heated and a short right-angle bend made about 1 ft. from the end with the web of the channel on the inside of the bend. A triangular piece of steel plate was then cut and welded inside the bend, as shown, to form a gusset plate and support.

A short length of 1½x1½x¼-in. angle iron was offset into the shape shown in the sketch and welded to the back of the channel to serve as a back stay.

The bracket was then attached to the wall with bolts going all the way through, one of them also holding the angle iron in place. Four more brackets were made in a similar manner and bolted in place. Effort was made to see that the tops of the brackets were as near in line as possible. The bearing blocks, which were of the self-aligning type, were then placed on the bracket and the shaft was put in place and lined up. Holes for the blocks were then laid off in the channel bracket with the blocks in place and drilled through the channel. When these holes were located, a recess or hole was



These emergency brackets were formed from scrap material.

When it became necessary to move a lineshaft quickly, these brackets were made by cutting, bending and welding scrap material. The plate, gusset and angle-iron stay give the necessary rigidity to the channel-iron bracket.

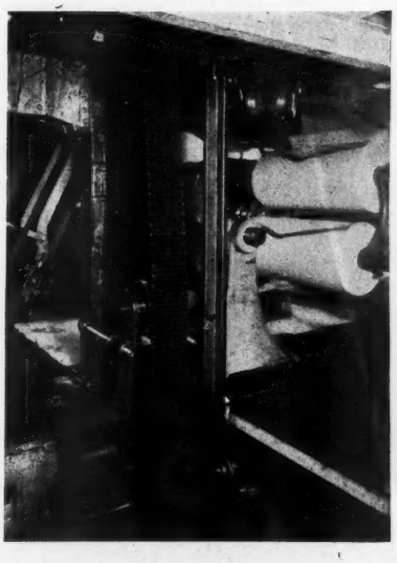
burned in the gusset plate, as shown, to take the nut of a §-in. bolt for holding the blocks in place.

By this means in a comparatively short time it was possible to change the lineshaft location without waiting until we could send for special type brackets. Also these brackets were made from what was practically scrap material.

MAURICE C. COCKSHOTT.
Arcadia, Calif.

Substituting a Long-Center Chain Drive for Bevel Gears and Shaft

THE problem of connecting two parallel shafts slightly more than 10 ft. apart by silent-chain drive was solved in an interesting manner in connection with a printing-press installation. The original drive of each of four sextuple printing presses at the plant of *The Milwaukee Journal* was from the motor to the jackshaft, which in turn drove six vertical shafts, each connected to a horizontal shaft through bevel gears. Each of these four presses was driven by a 100-hp. motor.



This vertical silent-chain drive eliminated 24 gears.

The chain operates on 128-in. centers driving a battery of 4 printing presses. A 33-tooth sprocket is used as an adjustable idler which is placed on the tight side of the drive. The idler pedestal frame is attached to the steel column and by means of threaded rods the idler is adjusted to provide the necessary chain tension.

The shaft-driven equipment, as originally installed, was not satisfactory because of excessive friction and high maintenance cost due to shaft and gear breakage. This was due partly to the peculiar construction of the drive and partly to the lack of headroom for suspending the motor.

Sometime ago this arrangement of vertical shafts and gears was replaced with a chain drive, which has proved satisfactory on the first four press installations and plans are under way for equipping companion presses in a similar manner.

The present drive is by means of a 1.2-in. pitch Morse silent-chain belt 10 in. wide. Four drives of this type have replaced the vertical shafts with their bevel gears. The chain operates on 128-in. centers and has a total length of about 26 ft. The driving jackshaft from the motor is underneath the floor and operates at 325 r.p.m. The driven shaft, overhead, which drives the presses previously operated by the vertical shafts and gears, operates at 300 r.p.m. The lower sprocket has 47 teeth and the upper sprocket 51 teeth, which give a chain speed of 1,525 f.p.m. By adopting this chain, three sets of gears have been eliminated on each drive, or a total of 24 gears for the four presses.

Because this was a vertical drive, which is one of the most difficult to operate successfully, due to the fact that any slack in the chain will tend to cause it to hang free from the lower sprocket, it was necessary to install an adjustable idler with a 33-tooth sprocket. This was placed on the tight side of the drive, as a steel building column is directly behind the slack side of the chain, thus preventing the use of the idler at that point. The idler was necessary to keep the vertical chain tight, and also because the presses are frequently stopped suddenly when the stop button is pushed by a pressman and with the idler so placed it prevents whip in the chain.

Engineers ordinarily hesitate to adopt a chain for a drive of this type, not only because it is vertical, but also because of the chain whip resulting from sudden stopping. It was only after a close study of the installation that the new arrangement was recommended. The operation is much smoother, practically noiseless, and the drive consumes less power than the previous installation. In addition, less than 5 per cent as much oil and grease as were previously necessary, are required for lubrication, and one less man is required for the maintenance of the press.

EARL C. MOSS.
Consulting Engineer,
Chicago, Ill.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Advantages of Replacing Broken Castings with Welded Steel Parts

BROKEN castings frequently require a long time to replace, whereas the broken part may, in many cases, be reproduced in welded steel construction within a few hours and at a fraction of the cost of a new casting. The accompanying illustrations show a number of more or less complicated parts, made of welded steel, that have been constructed and used in our plant.

Standard steel plate, tube, rounds, bar stock and structural shapes are cut as required and the assembly made by electric arc welding. Practically any casting may be reproduced by this method. The welding operator either works from dimensions taken from the broken casting itself or, in case modifications are to be made, from a pencil sketch. Any steel warehouse can supply all of the parts required, cut to size and ready to assemble, in a short time. In the machining operations, the welded steel piece is treated in the same manner as though it were a rough casting.

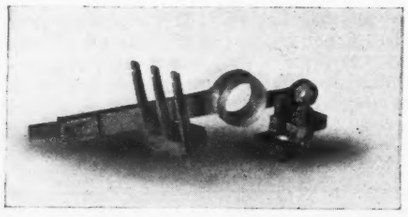
Operating men who have become familiar with the practice of making the welded steel equivalent of castings in many cases overcome defects of design in making the new parts. As steel is four or five times as strong in tension as cast iron, and two and one-half times as rigid, it is a better material for machine parts than is cast iron. Taking this superiority of steel into consideration and making slight changes in shape has in some instances eliminated trouble of long standing. Steel parts will seldom break—the worst that will happen is that the steel part will be bent out of shape by unusual stresses, in which case it may be restored to usefulness by straightening.

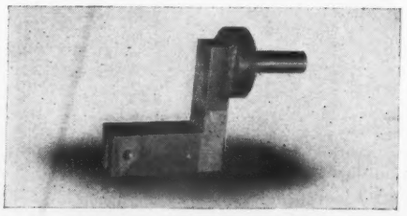
On account of the unbreakable feature of welded steel parts, together with their lower cost as compared with castings, an increasing number of machines are being built of steel instead of castings. This renders obsolete some machines that were formerly built of castings, so that for all practical purposes making spare parts of welded steel is the only method of repair.

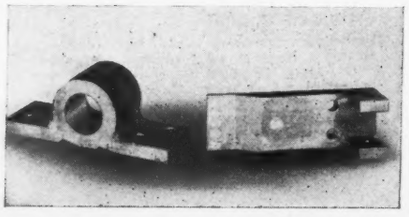
In case a plant is not already equipped with an electric arc welder, welded steel parts can be made in any commercial welding shop that is properly equipped. ROBT. E. KINKEAD.

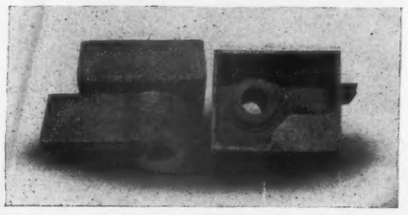
Chief Engineer, Welder Division,
The Lincoln Electric Co.,
Cleveland, Ohio.

These welded steel parts have replaced broken castings.









How to Rewind Small Headlight Generator Armatures

BEFORE rewinding ring-wound headlight generator armatures it is advisable to check the fiber insulation rings on each end of the core, and test the commutator for short or grounded bars. This will guard against any concealed defects during the stripping process.

These armatures have 20 slots and 20 bars. The leads throw one bar to the left of the mica segment on the center line of the slot for the starting lead, and one bar to the right for the finishing lead. The spider has four sections of five coils each; each coil has 19 turns of No. 16 wire. Combination fishpaper and treated cloth 0.015 in. is used for all insulation.

After stripping, the first step is to insulate the spider, making sure to cover the part of the armature which extends beyond the inside bore of the core, and allow enough fold under the core to make a lap joint on the inside. This insulation must be long enough to permit it to be flared up over the fiber insulating ring.

The cell insulation should be long enough to pull over the fiber when the wire is wound through it. All insulation must be glued in place.

These armatures must be wound in layers with no crosses either in the slots or inside the core. To start, cut a piece of wire about 6 in. longer than the amount required for one coil and, beginning in the first slot to the left of the section prepared, wind in one layer of five turns. Then pass to the next slot to the right, and so on until each has a layer of five turns without any crosses. Shellac each coil as you complete the layer.

Then return to the first coil and add another layer of five turns; if any crosses must be made, make them at the front end of the armature. Wind the second layer in all slots, as before. The third layer will make 15 turns; so the fourth and final layer will need but four turns to make the 19 turns required.

Lay the leads down in the proper slots, and if the commutator is not to be soldered, due to the extreme heat of the boiler, drive each side of the neck toward the other so as to hold the lead tightly. The armature may be held in a vise during the rewinding process. When varnishing an unsoldered armature care must be used so that the varnish does not get into the necks.

If the long ends of the wire are in the way while winding, they may be bent back onto a clean piece of paper.

Denver, Colo. CARL A. WAGNER.

Reinforced Slot Insulation Prolongs Motor Life

WE FORMERLY had many delays on our electric shovels due to breaking of rotor leads on the 125-, 150-, and 250-hp., 440-volt motors. There were also insulation failures on these leads on account of the fan blades shifting from their position by reason of excessive vibration.

At first we sent our rewinding jobs to reliable repair shops, but they failed to correct the fault. Eventually I persuaded our management that I could eliminate the trouble and was told to try my ideas on a 150-hp. rotor.

We always bought coils and rewinding supplies directly from the manufacturers and although these factory leads were nice to look at, with their square bends, they did not last long under the excessive vibration encountered on the shovel. They were made for motors located on a solid foundation and not on a swinging board. I constructed my

own leads of slightly heavier copper and was careful not to crack or strain the metal at the long, round bends. The slot insulation was cut 2 in. longer than the slot so that it extended beyond the iron, where it would usually break down.

I extended the slot paper ½ in. beyond the fan blades and slipped a piece of 0.015-in. Armco paper ⅞ in. wide and long enough to fold back over the fan blades under the slot paper on both ends. After the coils were in place and before the slot insulation was folded, I folded the strips over the fan blades and inserted another piece of ⅞-in. Armco paper, 0.015 in. wide, 4 in. long and bent in an inverted U-shape, over the fan blades, which were already covered by the strips under the slot paper. This gave me 0.010 in. in slot paper and the two 0.015-in. Armco strips in addition to the coil insulation. I made the band wider to catch the tops of these added strips, in order to hold them in position. The rotor was soaked in varnish twice, using General Electric No. 458 Black and No. 152 Clear, baking after each treatment. Orange shellac was then used for the finish coat.

Before I made these changes, we lost a lead every two or three weeks on one motor or another. Four months without trouble was a record run, but since this rotor was changed as described, it has been in service for 20 mo. without a patch and is still in good condition. Since then I have rewound a 125-hp. and a 250-hp. rotor which are also giving good service.

We have spare rotors for all motors and I am changing the slot insulation as fast as the rotors come up for rewinding or repairs. These motors are running about 30 per cent overspeed when they are "plugged," which raises the rotor voltage to about 1,100 or 1,200 volts. All rotors are tested in the shop with 2,300 volts and are made to stand it. I cannot give exact figures on the saving this change represents in money, but I do know that it saves us every year from 10 to 20 delays lasting from 4 to 36 hr. each. Inasmuch as our payroll amounts to about $60 an hour, there is a considerable saving in wages alone, aside from the cost of frequent rewinds. H. J. GARRISON.

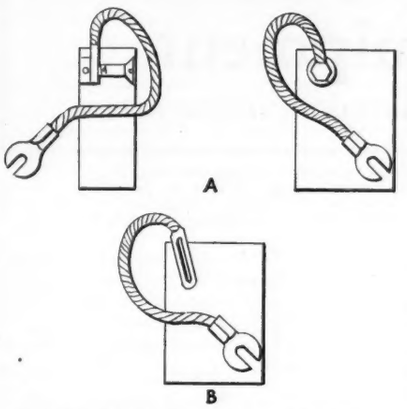
Electrical Maintenance Dept.
Pittsburg & Midway Coal Mining Co.
Pittsburg, Kan.

Simple Method of Making Carbon Brushes in Emergency

OFTEN it is necessary for the plant electrician to make a few brushes for a certain machine; so if he is prepared for this emergency he will have in stock a few sheets of high-grade carbon suitable for such uses. These sheets come approximately 4 in. x 5 in. in size and of any desired thickness.

To make the brushes, lay off the desired number of brushes on one or more sheets, allowing a fair margin for finishing after cutting them out roughly with a hacksaw or carbon cutter. The latter is a very thin emery wheel or small steel saw.

The finishing should be done on a machined flat surface using No. 0 or No. 00 sandpaper to remove the excess carbon. The edges should then be beveled slightly and all sides smoothed down except the contact end, which is ground to the approximate curvature of the commutator or slip ring. A pattern may be made by laying off the radius of the commutator or slip ring on a piece of heavy paper. If the radius is made slightly smaller than the commutator and the brush is rough cut to conform to this arc, it will make the brush easier to fit when sandpapering on the commutator.



Brush shunts may be attached by machine screws, as at *A*, or by pinning them, as shown at *B*.

Attaching the shunt or pigtails to the brush, as shown in the illustration, is the next step. The shunt leads may be made up of flexible bare copper wire plaited if desired and insulated with sleeving or glass beads. For brushes ⅜ in. thick or over the quickest method is to use small machine screws with flat heads, and nuts. Countersunk holes are drilled in the side of the brush near the top, as shown at *A*, allowing the shunt to clear the side of the brush when the screw is set up tight.

Another method of fastening shunts in smaller brushes is to drill a hole in the top as at *B*, of a size that will admit the shunt when twisted. The shunt is then secured by driving a pin into it while the brush is clamped in a vise. I have found it good practice to drive the pin in half-way and then cut it close to the brush and drive it in flush, being careful, however, to prevent breakage. GRADY H. EMERSON.

Birmingham, Ala.

Wiring and Construction Details of Handy Test Panel

A TEST panel which can be put to a variety of uses was recently built in our shop and mounted on the rear of the workbench. It was made from a Transite board measuring 60 in. x 30 in. x ½ in. on which we mounted the appliances used in ordinary testing. Three separate sources of power are brought to this panel and all fused according to the requirements.

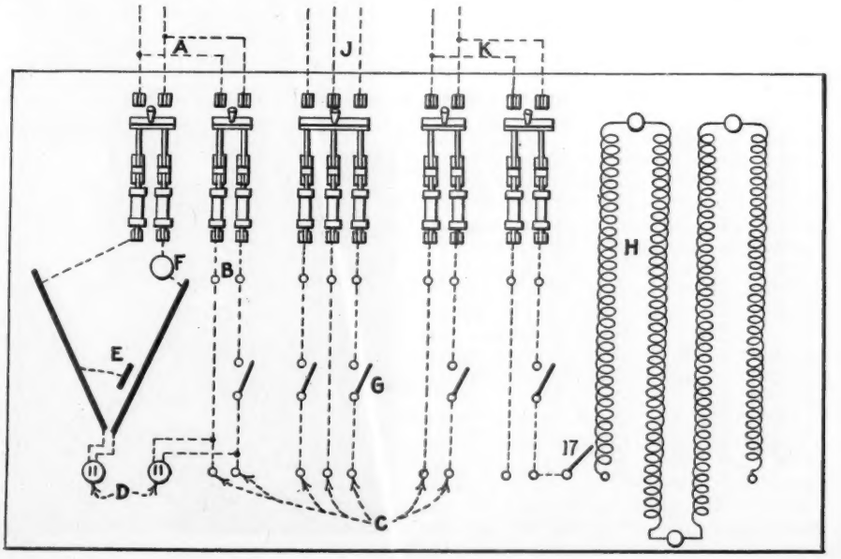
The diagram shows the connections for the equipment used. The single-phase, 115-volt a.c. circuit at *A* serves voltage plugs *B*, outlet plug *C* for connecting apparatus to be tested, plug receptacles *D*, the rack *E*, and lamp receptacle *F* for testing fuses. The three-phase, three-wire circuit at *J* serves, through its knife switch and fuses, voltage plugs *B* and outlet plug *C*. Short-circuiting switches, *G*, are provided for ammeters. The 125-volt d.c. circuit at *K* provides service to the outlet plug *C* through ammeter switches *G* and a tapped resistance *H*. The tapped resistance is used chiefly in the charging of storage batteries, but it can be disconnected and used for any other desired purpose.

For fine resistance work we use a General Electric variable testing rheostat that can be tapped in the current taps of any circuit, and through the resistance we can obtain a range of current from 0 to 30 amp. in 0.5-amp. steps. We have an old 2,200/100-volt instrument potential transformer, inverted, which enables us to do low-potential testing, when necessary.

E. J. MORRISSEY.

Chief Electrician,
Western United Gas and Electric Co.
Aurora, Ill.

The test panel was laid out and wired as shown in this diagram.



New Equipment

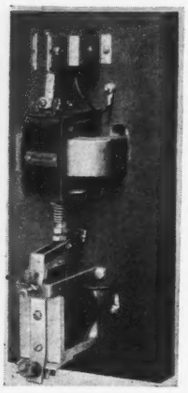
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Step-Back Relay

A NEW step-back relay introduced by the General Electric Co., Schenectady, N. Y., is designed for use with direct-current magnetic control equipment to provide overload protection and to allow a suitable time delay before resetting.

The upper part of this relay consists essentially of a normally closed contact, whose open or closed position is controlled by a coil in series with the motor armature. Loads in excess of the relay setting cause this normally closed contact to open, dropping out the step-back and accelerating contactors and thereby inserting enough resistance to limit the motor current to 125 per cent of normal full-load current with locked armature.



The lower part of the relay, it is claimed, prevents the overload mechanism from resetting until after a definite time interval. If, after this definite time delay the motor current has decreased to a safe point, the overload mechanism resets and the control panel automatically accelerates the motor in the regular manner. The relay will not reset unless the current decreases below a certain point. In this event, the motor will have to be disconnected from the line and restarted from rest.

Electric Hoist

ANNOUNCEMENT is made by the American Engineering Co., Philadelphia, Pa., of a new Lo-Hed electric hoist that can be mounted in a fixed position either overhead or on the ground, or can be placed on skids and used as a portable hoist.

The standard machine consists of a smooth drum driven by a motor through a train of spur gears, all mounted on a common bedplate. It is furnished in sizes for handling loads from 500 to 4,500 lb. The gears are of drop forged steel, heat-treated, and run in an oil bath. Hyatt roller bearings are mounted on the ends of all gear shafts. The motor and gears are completely inclosed.

The drum has large flanges which prevent the rope from jumping off the ends and give maximum stowage capacity. One bearing of the drum shaft is lubricated by splash from the gears, and the other by an Alemite fitting. Either d.c. or a.c. fully-inclosed, ball-bearing motors especially designed for hoist service can be furnished with this equipment. The controller is of the single-speed, reversing-drum type.

Convertible Power Panel

A NEW type power panel, shown in the accompanying illustration, has been announced by the Square D Co., Detroit, Mich.

This panel embodies a novel feature in having all the fuse clips and jaws mounted on individual insulating bases. With this arrangement it takes but a few minutes to remove and replace a burned fuse jaw from the front of the panel. In order to convert the circuits from 30- to 60- or 100-amp. fuse spacings it is necessary only to loosen a few nuts holding the supporting grids, when the individual bases can be quickly moved to the correct spacing, as indicated on the grids.

Test jacks are provided in each circuit. These are mounted on individual insulating bases and holes are provided in the cabinet door so that the test plug can be inserted into the jack without opening the door. When the plug is not inserted, the opening in the door is kept closed by means of a sliding cover.

The cabinet is of the duplex design, for column mounting, with doors on each side of the cabinet. The main busbars are brought down the side of the cabinet and in this way it is possible to place half the total number of circuits on each side of the cabinet. This construction reduces the size of the cabinet considerably.

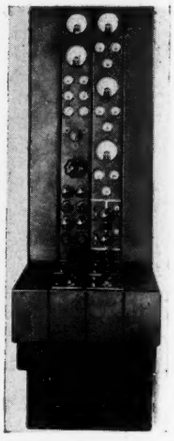
A compartment at the top or bottom incloses the main lugs, which are set at an angle, making it easy for the connections to be made. All cabinet trims are hinged so that it is a one-man job to get access to any of the gutters.

New Design of Power Panel Manufactured by the Square D Co.

Miniature Control Desk

THE development of a miniature control desk, which consists essentially of standard equipment in a compact form, has been recently announced by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

This type of desk is made of ¼-in. stretcher level steel. The indicating wattmeters, reactive factor meters and power factor meters are approximately 4 in. in diameter, and have the same movement as the larger and more frequently used switchboard instruments of 5½ in. and 7½ in. diameter. The ammeters and voltmeters are all approximately 2 in. in diameter, and are of the flush type.



The accompanying illustration shows the two end sections left blank. The second section from the left is for the control of a large turbo-generator and includes all instruments and control equipment necessary for the generator including its direct-connected exciter, field circuits and regulator. It is also provided with controllers for the field switches so that the generator fields can be connected either to the direct-connected exciter or to a spare exciter bus. All control switches are of the standard type and small, telephone-type indicating lamps are used.

The adjacent panel controls three feeders, each feeder is equipped with a polyphase wattmeter, three ammeters, two control switches with red, green and white indicating lamps and synchronizing key interlocks. The control desk is completely equipped with miniature busbars and cardholders for the main connections.

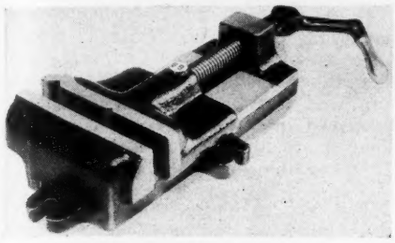
Machine Vise

A WIDE range of adaptability is claimed for the new BB machine vise manufactured by the Brown Bros. Machine Co., 815 East 93rd St., Cleveland, Ohio. The body and jaws of this vise are of tough gray cast iron, the screw is of machine steel, and the handle is of cast steel.

To facilitate difficult set-ups on the machine, such as bolting the vise in a vertical position on an angle-plate, the top, bottom, and sides of the vise, it is claimed, are carefully machined after assembly, and thus facilitating the set-

ting of work. Broad bearing slides and gripping surfaces, it is claimed, together with the large square thread screw, eliminate shake and shifting of the work under heavy cuts. The cast-steel handle is permanently attached to the screw and is pivoted.

Outstanding features of the vise are the pair of milled V-slots set vertically



BB Machine Vise Manufactured by the Brown Bros. Machine Co.

with the jaws and the 1¼-in. overhang that permits handling a variety of work, which must hang below the machine table. The outer and larger V-slot is approximately in the center of the overhang. The second V-slot is smaller and is located in the portion of the jaw above the jaw-slide.

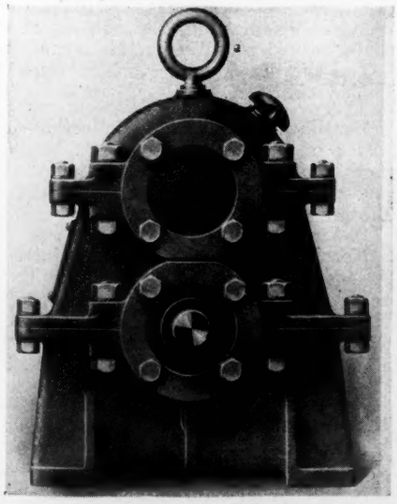
Three lugs are provided. These are flat on the top for use with dogs and are also slotted to take bolts up to ½ in. in diameter. The over-all dimensions are as follows: Length, 17.5 in.; width, 7 in.; jaw opening, 4 in. The jaws are 6.5 in. long and 1¾ in. deep. The net weight is 25 lb.

Helical Gear Speed Reducer

ANNOUNCEMENT is made by the R. D. Nuttall Co., Pittsburgh, Pa., of the development and marketing of a complete line of speed reducers ranging from 1- to 150-hp. rating and known as the SVR series. These are fitted with Nuttall 7½-deg. helical gears and Timken roller bearings. The SVR series comprises single-reduction units with reduction ratios ranging from 1:1 to 8:1.

These reducers represent a new adaptation of low-angle helical gears. Ac-

Nuttall SVR Series Speed Reduction Unit.



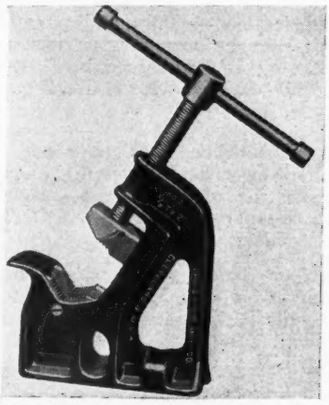
cording to the manufacturer, they have numerous advantages over other types of gearing, such as efficiency, strength and smoothness of driving. One of the greatest advantages of helical gears is their ability to resist external thrust.

In these new reducers the high- and low-speed shafts, which are parallel and offset in the same plane, are carbon steel forgings with the pinions integral, although shafts and pinions of alloy steel can be furnished if desired.

The reducer case is cast iron with the bottom providing a settling basin and a reservoir for oil which is picked up by the gear teeth and thrown by centrifugal force into oil troughs that lead to the different bearings.

Side-Opening Vise

ANNOUNCEMENT is made by the Oster Mfg. Co., Cleveland, Ohio, of a new inclined, side-opening pipe vise which, it is stated, grips and releases the pipe with one turn of the handle. This new vise is equipped with oil-tempered, tool-steel jaws which, it is claimed, are so designed that they will grip the pipe securely without danger



Oster Mfg. Co. Side-Opening Pipe Vise.

of squeezing it out of round. The vise is shown in an accompanying illustration. A special chain and clamp for fastening the vise to a post are furnished for use where it is not possible to bolt the vise to the workbench. Another useful accessory is a special eye-bolt for pipe bending. This new vise has a range of ⅛- to 2½-in. pipe, and the jaws open wide enough to accommodate a 2-in. coupling so that short nipples can be handled.

Conduit Bushing

UNUSUAL corrosive-resisting properties are claimed for the new CWP stamped electric conduit bushing recently placed on the market by the Cleveland Wrought Products Co., Cleveland, Ohio.

These bushings are cadmium plated and it is stated that, in consequence of the inherent properties of cadmium, they will remain unaffected under conditions that would speedily destroy galvanized bushings, because, being strongly adherent, the coating has no tendency to flake off or to disintegrate.

Combination Grinders and Buffers

TWO of the eight new models of Hisey combination grinding and buffing machines, which are built with 1- and 2-hp. motors are shown in Figs. 1 and 2. Fig. 1 shows the machine equipped with an open-type spindle ex-

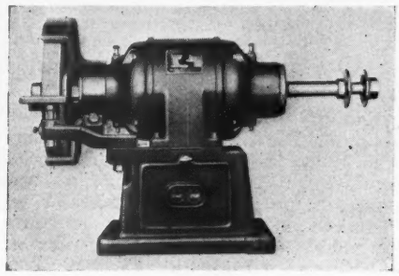


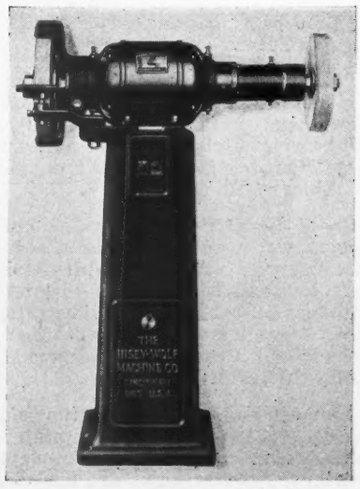
Fig. 1 — Hisey-Wolf Grinding and Buffing Machine With Open-Type Spindle.

tension for use when necessary to do close, corner work. Fig. 2 shows the machine equipped with encased-type spindle extension which, because of its rigid double-ball-bearing construction is recommended for heavy-duty, buffing, polishing and scratch-brush work.

The 40-deg., single-phase, alternating-current motors are of the improved commutating repulsion-induction type, which has no centrifugal switch. They will start and pick up speed almost instantly under any load within twice their rated capacity, it is said. Starting current under all conditions is unusually low, being less than one-third the current consumption of split-phase motors.

Two- and three-phase alternating-current machines are equipped with motors of squirrel-cage design. The bearings are described by the manufacturers as high-grade, oversized ball bearings, mounted in endheads in close proximity to the wheels. All bearings are completely enclosed for protection from dust and grit. A motor starter with push-button control is standard equipment on every Hisey grinder and buffer.

Fig. 2 — Hisey-Wolf Grinding and Buffing Machine With Encased-Type Spindle.



Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Babbitt—A revised edition of the Magnolia Bearing Metal Handbook has just been published. This handbook comprises 96 pages of data, illustrations, suggestions and instructions on the selection and preparation of bearing metals for various kinds of service. —Magnolia Metal Co., 75 West St., New York, N. Y.

Glass—The composition of Pyrex glass and its many applications in industry are described and illustrated in a bulletin recently issued by this company.—Corning Glass Works, Corning, N. Y.

Blowers — Bulletin 2004 describes and illustrates a steel plate blower, known as Type S.E.—American Blower Co., Detroit, Mich.

Belting Manual—About 17 pages of practical engineering information on leather and leather belts for belt users and belt buyers are contained in the G. & K. Belting Manual.—Graton & Knight, Worcester, Mass.

Reelite—Bulletin 501 lists, describes, and gives prices of the entire line of constant-duty Reelites or automatic, spring-driven, take-up reels for electric cables. A large number of installations are illustrated.—Appleton Electric Co., 1718 Wellington Ave., Chicago, Ill.

Welding and Cutting Equipment—The 1927 junior catalog, pocket size, lists and describes briefly the various units of Smith acetylene welding and cutting equipment. — Smith Welding Equipment Corp., 2619-33 Fourth St., S.E., Minneapolis, Minn.

Silent Chains—Considerable engineering data and descriptions of a number of installations of Whitney silent-type chains for power transmission are given in a 76-page booklet.—The Whitney Mfg. Co., Hartford, Conn.

Pulleys—A circular lists the advantages of Pyolt Red Face pulleys, flywheels, and gears, as well as the Pyott ball-bearing, tight-and-loose pulleys.—Pyott Foundry Co., 328 N. Sangamon St., Chicago, Ill.

Speed Reducers—The line of Philadelphia worm and spur-gear speed-reduction units, together with flexible couplings and bedplates, is covered in Catalog 14. Numerous illustrations show some interesting applications.—Philadelphia Gear Works, Richmond & Tioga Sts., Philadelphia, Pa.

Exhaust Fans—The Sturtevant slow-speed, low-power, planing mill exhauster for collecting and conveying shavings, sawdust, chips and dust from emery and buffing wheels, and similar materials, is described in Bulletin 303. —B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Pipe Tools—Pipe tool Catalog B-10 describes and illustrates this company's complete line of stocks and dies, pipe cutters, pipe vises, chain, pipe tongs and pipe wrenches. — The Armstrong Bros. Tool Co., 317 N. Francisco Ave., Chicago, Ill.

Air Filters—Detail sheets bound in catalog form describe and show by sketches the instructions for installing Midwest air filters. — Midwest Air Filters, Inc., Bradford, Pa.

Lubrication — Pulp and paper mill lubrication by the Bowser system is illustrated and explained in a 12-page bulletin.—S. F. Bowser & Co., Inc., Fort Wayne, Ind.

Lock Washers — Shakeproof lock washers of various types are described in a series of circulars.—Shakeproof Lock Washer Co., Inc., 2501 N. Keeler Ave., Chicago, Ill.

Safety Switches — New and revised listings of all safety switches, residence and unit panels, and panelboards, are given in Bulletin 7.—The Trumbull Electric Mfg. Co., Plainville, Conn.

Spray Painting—A number of loose leaf sheets describe maintenance painting by the Vortex method.—The Vortex Mfg. Co., 1986 W. Seventy-seventh St., Cleveland, Ohio.

Couplings—Bulletin F illustrates and gives ratings for the different sizes of Fawcus flexible, universal, adjustable thrust, and mill-crab couplings.—Fawcus Machine Co., Pittsburgh, Pa.

Pneumatic Tools—Catalog 8 describes the complete line of Keller Super pneumatic tools, including such specialties as a saw attachment for an air drill.—William H. Keller, Inc., Grand Haven, Mich.

Glass Insulators—The complete line of glass insulators for telephone, telegraph, electric light, and power distribution for voltages up to 11,000, is covered in a new catalog.—The Hemingray Glass Co., Muncie, Ind.

General Catalog—The New General Catalog 30 contains 960 pages and includes the complete line of conveying, elevating, screening, and transmission machinery manufactured by this company. Descriptions and technical information are supplemented by illustrations and drawings, much of it in two colors. To obtain, please give name, position, company name, and complete address. — Catalog Dept., Stephens-Adamson Mfg. Co., Aurora, Ill.

Tachometers—The line of O-Z hand and stationary tachometers for indicating operating speed is described in a booklet.—O. Zernickow Co., 15 Park Row, New York, N. Y.

Worm-Gear Speed Reducers — The newly designed IXL HyGrade worm-gear speed reducers, which are completely equipped with ball bearings and improved facilities for lubrication, are described in Catalog 300.—Foote Bros. Gear & Machine Co., 220 N. Curtis St., Chicago, Ill.

High-Voltage Transformers—Moloney single-phase and three-phase transformers up to 100-kva. rating in 25- and 60-cycle designs for voltages from 17,500 to 45,000 are described in a 12-page bulletin.—Moloney Electric Co., St. Louis, Mo.

Copperweld Steel—A folder describes the advantages claimed for Copperweld steel as the result of the method of manufacture.—Copperweld Steel Co., Braddock P. O., Rankin, Pa.

Roller Chain—Industrial Booklet 102, entitled "Rolling the Problems Out of Transmission," illustrates and gives the operating advantages claimed for the use of Diamond roller chains for power transmission.—The Diamond Chain & Mfg. Co., Indianapolis, Ind.

Compressed Air Cleaners—Bulletin 227 describes the various Nicholson devices for removing moisture, oil, and dirt from compressed air. — W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa.

Leather Belts—The manufacture of leather belting, together with complete instructions for the operation and maintenance of leather belting, engineering data, horsepower tables and other information, are contained in a new, 96-page, two-color, illustrated catalog. The complete line of mechanical leathers and other leather goods manufactured is also included.—Chicago Belting Co., 110 North Green St., Chicago, Ill.

Tramrail Systems—A diagrammatic layout of a Cleveland Tramrail System in a rubber plant in the subject of a folder issued recently by this company. —The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Ventilation and Dust Collection—A series of bulletins discuss the Norblo method of dust collecting and handling, and ventilating systems. — Northern Blower Co., Cleveland, Ohio.

Herringbone Gears and Gear Units—A loose-leaf catalog describes the Farrel line of Sykes continuous-tooth, herringbone gears and their application in reducers and other gear units.—Farrel Foundry & Machine Co., Buffalo, N. Y.

Electric Hoists — Circulars describe the Emerman line of Universal ball-bearing electric hoists in 500, 1,000, and 2,000-lb. capacities.—Louis E. Emerman & Co., 1761 Elston Ave., Chicago, Ill.